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[FROM ENGINEERING.]

ARMSTRONG QUICK-FIRING GUNS.

THE famous firm of Elswick can with unquestionable justice claim to have taken the lead in the construction and design of quick-firing guns of large caliber, and has maintained its position in this important branch of artillery.

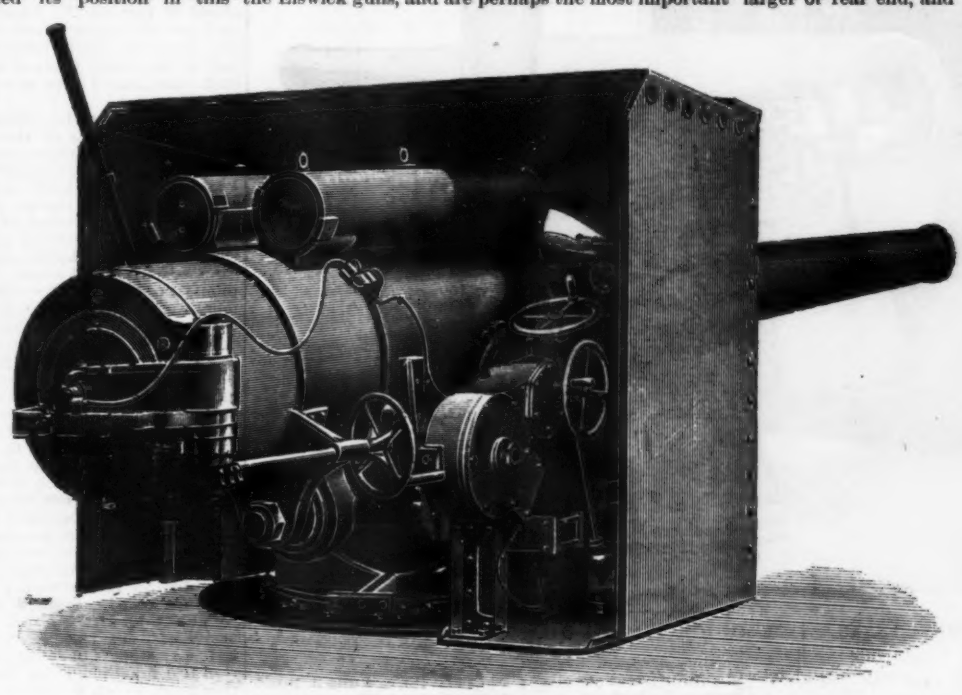
Important alterations or modifications have from time to time been introduced, so that the quick-firing guns of to-day differ materially in detail from those that were first produced in 1886. The modifications referred to have taken place in nearly every detail that goes to make up the complete gun and mounting; for instance, comparing the quick-firing gun originally designed with those now under manufacture, we find that the caliber of the guns has advanced from 4·7 in. to 6 in., or it may indeed be said (as will afterward be explained) to 12 in. The protecting shields, originally of 1¼ in., have now in some cases reached 6 in. in thickness, the shape of the shield being also modified to give better protection; and the breech mechanism has been improved so as to give a higher rate of fire.

With a charge of 12 lb. of pebble powder (ordinary black) a velocity of about 1,800 foot-seconds is obtained, giving to a projectile weighing 45 lb. an energy of 1,010 foot-tons. This velocity was considered very satisfactory a few years ago, but now appears low in comparison with the 2,100 foot-seconds obtained from the same gun with a charge of only 5½ lb. of cordite, and producing an energy of 1,375 foot-tons. Here a charge of cordite of less than half the weight of the ordinary powder charge develops 36 per cent. more energy. Again, taking the 6 in. quick-firing gun, the ordinary powder charge is 34 lb., which gives to a projectile weighing 100 lb. a velocity of about 1,970 foot-seconds, or an energy of 2,690 foot-tons; the cordite charge of 15 lb. develops a velocity of 2,200 foot-seconds, or an energy of 3,356 foot-tons, this being nearly 25 per cent. in excess of that due to the charge of ordinary powder.

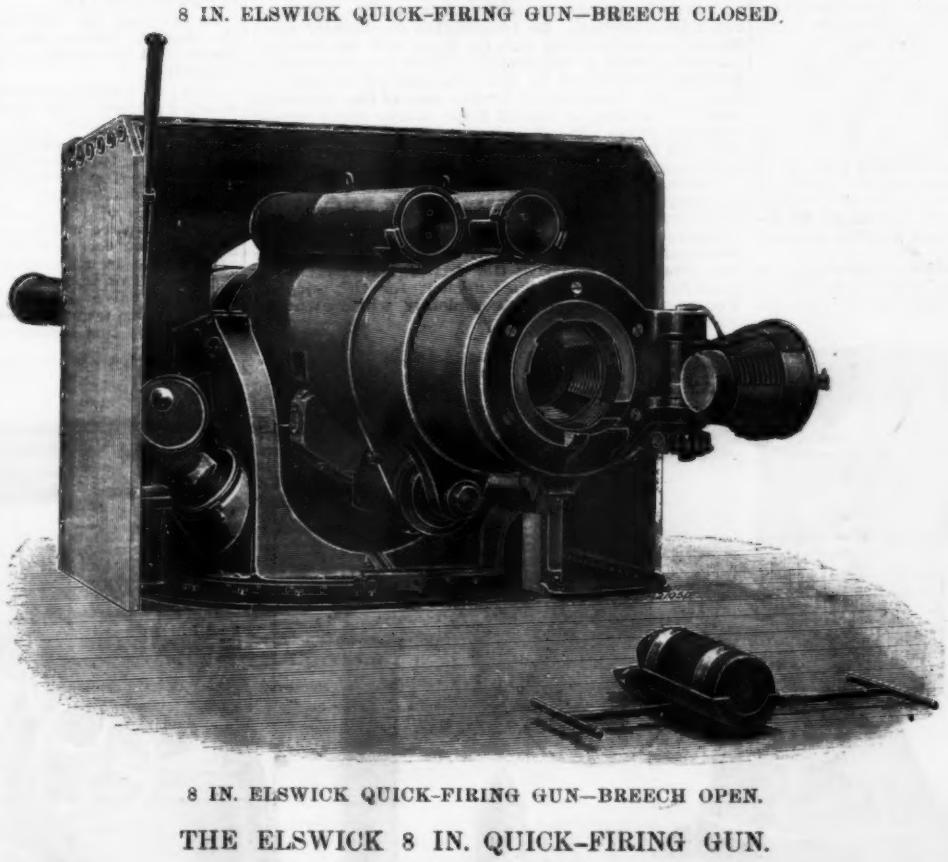
In both the above cases the chamber pressures due to the cordite charges are lower than those produced by the ordinary powder charge, and it must not be forgotten that the mounting receives comparatively less strain; for the energy of recoil with the light charge of cordite would be less per foot-ton of energy of shot than it would be with the heavier charge of black powder.

Cordite is so called because of its appearance. It is manufactured in lengths, having a circular section, the diameter of which varies from that of a very thin string for rifle caliber arms to that of a thick cord for the larger sizes of artillery. Its manufacture does not concern us at present; it will suffice to mention that cordite is a mixture of nitro-cellulose and nitro-glycerine, with a small admixture of mineral matter. All the experiments have shown very conclusively that cordite is one of the most satisfactory of all the different types of smokeless powders yet introduced.

We will now give a description of the Elswick modern quick-firing guns, explaining as we proceed the reasons for the modifications that have taken place in the original design. As the guns are all made on the same principle, it will be best to select the largest, the 6 in., as the typical one for description, and to commence with the breech arrangements, which are a specialty of the Elswick guns, and are perhaps the most important feature of quick-firing guns. The breech screw is on the principle of the interrupted screw, but the front portion is tapered, the rear portion being cylindrical. By this arrangement two advantages are secured—first, the action of opening and closing the breech is much simplified, as the withdrawal and bringing away of the breech screw can be done in one motion instead of two; and, secondly, the cone shape enables the screw not only to take hold of the inner surface of the breech hoop and jacket, but to distribute the engagement, and therefore the strain and support, over a much larger portion of the transverse section of the gun. The breech screw is further arranged so that the threads of the smaller or coned end correspond longitudinally with the interrupted or plain spaces of the larger or rear end, and *vice versa;* thus the strain is also distributed throughout the entire circumference of the breech screw, instead of, as formerly, half the circumference being lost by the interrupted spaces. The coned breech screw passes on to the central projection of the carrier from the front, and is prevented from coming off by a bolt. This bolt screws into the breech screw, and has a plain end fitting into a groove, which is cut in the carrier at the same pitch as the threads of the breech screw, and which is long enough to allow the bolt to be turned for screwing up the breech.



8 IN. ELSWICK QUICK-FIRING GUN—BREECH CLOSED.



8 IN. ELSWICK QUICK-FIRING GUN—BREECH OPEN.

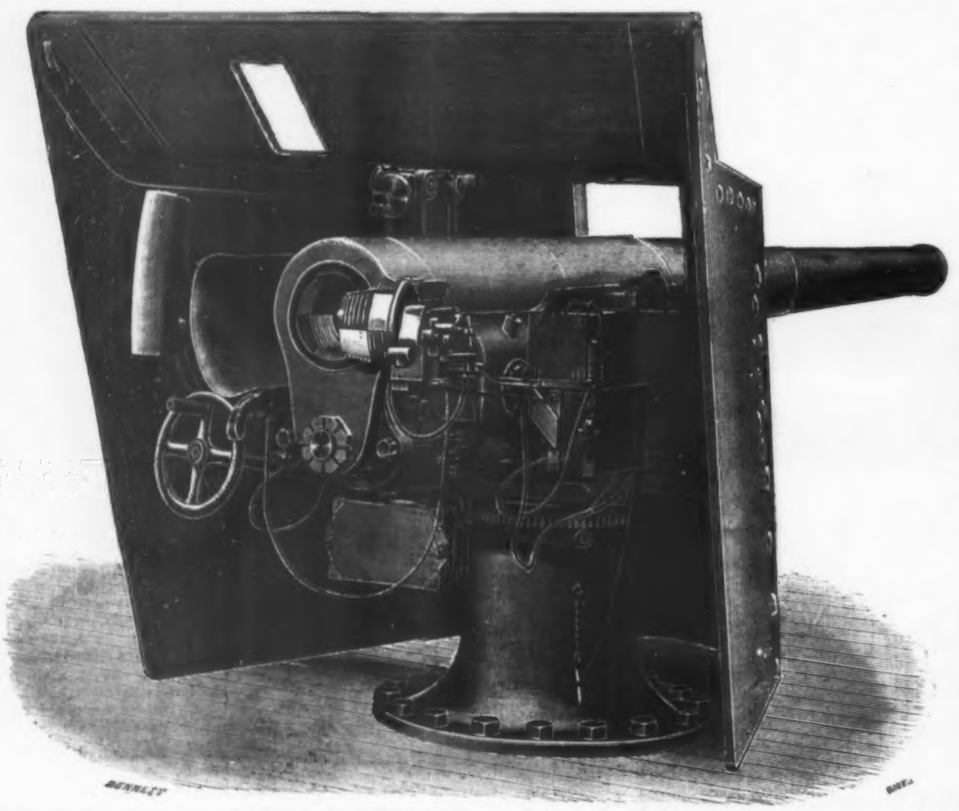
THE ELSWICK 8 IN. QUICK-FIRING GUN.

To operate the gear there is a band lever on the lower side of the breech screw, which works always in a horizontal plane; it pivots on the carrier, and is attached to a sliding block by means of a connecting rod. A pin in the breech screw works in a vertical slot in the sliding block, so that a horizontal motion of the latter causes the breech screw to turn. The centers about which the gear works are on their dead points when the screw is closed, and it is therefore perfectly locked. The lever, if swung round, first unscrews and then brings away the breech screw. It will be seen that the coned screw is particularly well adapted to this system, for there are only two motions for it to pass through, and these are readily combined so as to give the operator but one. With the parallel screw matters are different, for, in addition to the two motions required with the cone screw, there is a long motion of withdrawal. Three motions can only be combined in a single one by a compound lever, which must also be moved through a large arc.

As regards strength, there is, of course, no doubt that a parallel screw would be stronger than a coned screw of equal length, and equal diameter at the small end; but there is no difficulty in adding to the length of the coned screw, so as to obtain the same strength as is given by a parallel screw of a given length. It might be argued in the same way that a full screw is more than double as strong as an interrupted screw of the same length and diameter, but the advantages to be obtained by the use of the interrupted screw are very great and it is adopted with the necessary and easy condition of proportionately increasing its strength.

But there is a considerable portion of the Elswick breech screw which is parallel, and the fact of coning the front portion causes the rear parallel portion to be of much larger diameter than if the screw were entirely parallel. Thus the section of each turn of thread is greater, so that the parallel portion of the Elswick screw gives a large total section of thread in a short length of axis. Taking this into consideration, the total length of the Elswick screw is about the same as the total length of a parallel screw of equal strength, and as the coned

screw can very readily be lightened by boring it out from the rear, the weights of the screws on the two systems are also about equal. Besides the great advantage of requiring only two motions for withdrawal or insertion possessed by the coned screw, there is a decided advantage gained by the distribution of the strain over a larger area of the breech hoop into which the screw gears. This was very clearly shown by experiment. Longitudinal sections of breech screws geared into tubes were constructed; the sections of the tubes having previously been marked with lines at right angles to their axes, heavy stresses were applied to pull the breech screws to the rear. Under the action of these stresses it was found that with the parallel screw the lines became distorted, showing that the in-



THE 4 IN. ELSWICK QUICK-FIRING GUN.

terior layers of the tube had to bear the strain, the outer layers not being similarly strained. This distortion was not marked in the same way when the model of the coned screw was similarly experimented upon.

Another experiment to test the resistances of coned and parallel screws by the application of hydraulic pressure showed that the calculations were quite correct, and that the two screws yielded at the same point. This experiment was carried out by applying increasing pressures for certain periods. When these pressures became high, it was found that, although the coned screw was perfectly free to open each time the pressure was relieved, such was not the case with the parallel screw, which became very stiff as the final pressure was approached. It is very difficult to account for this result by theory, but practice showed that it exists beyond all doubt.

The Elswick coned screw embodies another feature of very great importance, which is, however, independent of the actual coning. We allude to the arrangement, due to Mr. Vavasseur, by which the interrupted sections on the coned portion correspond to the uninterrupted sections on the parallel portion. The stress is thus distributed throughout the whole circumference of the screw and of the breech hoop, a much more favorable condition than is obtained with the ordinary parallel screw.

These explanations ought to show that, if properly calculated, the coned screw has great advantages, and that the calculations are correct has been shown, not only by experiment, but also by the fact that more than a thousand guns have now been fitted with them, and no failure has as yet been recorded.

The extractor is an important item in the mechanism of guns using cartridge cases. It must be simple, strong and effective; but with large guns it must have a limited action in comparison with such guns as 3 and 6 pounders, for with the latter the extractor can advantageously be constructed to entirely eject the old cartridge case, and no harm will be done by its falling freely to the ground. With the larger guns, however, this cannot be allowed, both for the convenience of the gunners and for the sake of the cartridge cases themselves, as one of these heavy cases would certainly crush a man's toes if it fell upon them, and it would be badly distorted if it fell freely and struck hard ground or the deck.

For these reasons the extraction is arranged in the large quick-firing guns to take place in two motions. The cartridges are infallibly started by a very powerful extractor, which only has sufficient motion to insure their being free for the remainder of the extraction, the conical shape of the cartridge and chamber rendering a small motion sufficient for this purpose. The cartridges are then completely withdrawn and laid on the ground by means of a hand extractor, which readily fits over and firmly holds the primer.

The mechanical extractor is worked by the carrier in opening the breech screw. It consists of a rod passing through one side of the gun and fitting into the groove for the rim of the cartridge case, in such a manner that, when it is turned about its own axis, the fitted part acts as a lever and prises the cartridge to the rear. The extractor is brought back into its place, as the breech is closed, by means of a strong helical spring outside the gun; this spring also serves as a buffer to prevent the breech screw and carrier being swung too violently round. The extractor is fitted either on the right-hand side or the top of the chamber, so that it is out of the way of loading, or damage from the projectile, when the latter is being entered.

ON A FLUID PRESSURE REVERSING GEAR.*

By Mr. DAVID JOY, Member.

WHEN I last had the honor of reading a paper on the simplification of valve gears before this institution, I concluded by saying, "and I am continuing my investigations in the same direction, with a very tangible hope that I shall be able very shortly to take a step further in the simplification of valve gears by about 30 per cent." That was in 1886, or eight years ago, and the paper which your council have done me the honor to accept for my reading to-night is the result of the eight years of work in that direction since that date, and I hope it will not be without interest to you.

When I made the statement quoted I had in my view the treatment of the valve gear of marine engines, which were then increasing in size and speeds of revolution with such rapid strides, on a plan on which I had long ago designed and constructed reciprocating steam and water power machinery with satisfactory success, by abandoning all direct mechanical connection between the piston and the valve, and actuating the valve directly by the motive fluid driving the engine, so arriving at about the ultimate limit of simplicity possible in this direction. Many steam hammers were made on this plan, and gave very satisfactory results, being extremely sensitive and perfectly controllable for the most delicate blows, even to picking a wafer off a watch glass without breaking the glass. Thousands of steam pumps have also been made on the same plan, the valve being driven either by steam or water with no mechanical connection.

The great simplicity of the plan recommended it strongly for application to marine engines, and if successful promised a large field. But after some years' work in that direction I laid the plan aside, for the time only, I hope; not because of any mechanical difficulties in it that could not be overcome, but that the commercial element was not promising. It was, in fact, an advance, I think, too far in advance to find favor, a departure from ordinary practice too wide to be acceptable to either owner or builders. So, taking a medium course, instead of driving the valve itself by fluid pressure, where the fluid would always be in active motion, I proposed to myself to take only the half way step at once and to adjust and retain in position the machinery for moving the valve by the motive fluid, which would so mostly be in the condition of a static force only.

In carrying out this idea I returned, of course, to the absolute contact plan, driving the valve by a rod direct from the crank axle, but only one rod and one eccentric.

And now I shall not trouble you with the process by which I arrived at the result, but at once describe to you the machinery.

The principle of construction is simply that, in place of employing two eccentrics, set each at the proper positions, for giving forward and backward motion, and all intermediate points of "cut-off" necessitating the employment of the "motion link," and all the machinery required to move and hold it in position, I employ but one eccentric set upon the crank shaft and arranged to be slid across it between the two points, for forward or backward motion, and one rod direct up to the valve spindle. The method by which this sliding action is accomplished will be described immediately. By this arrangement all the requirements of

* Paper read before the Institution of Naval Architects, and given in *Engineering*.

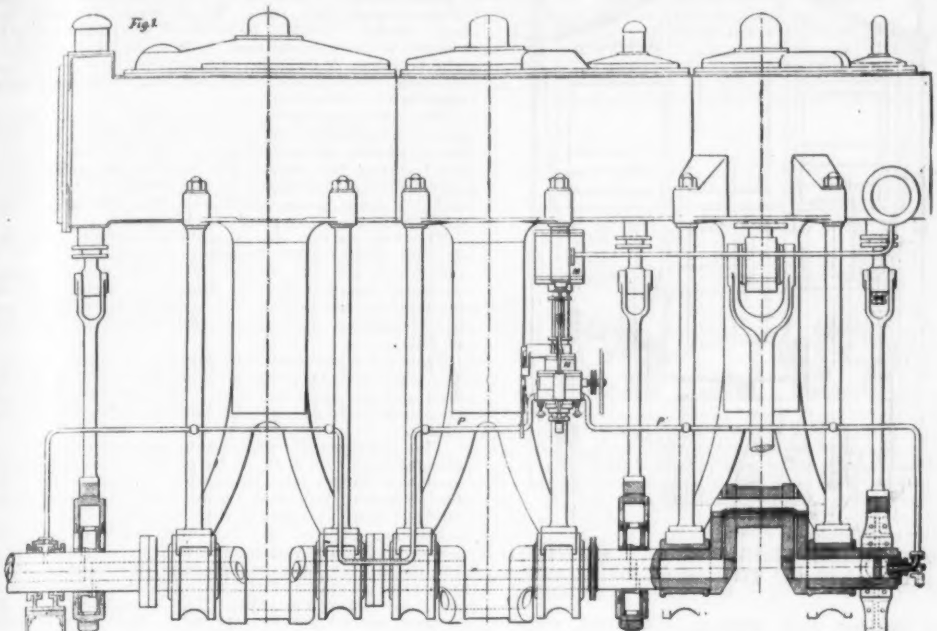
THE 4·7 IN. ELSWICK QUICK-FIRING GUN.

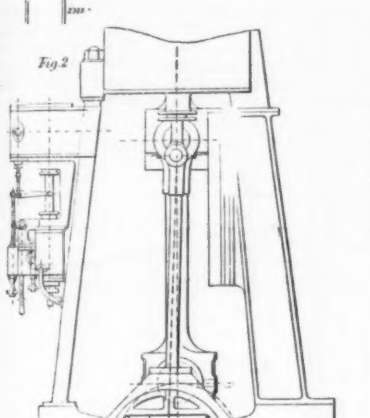
ELSWICK 4 IN. QUICK-FIRING GUN, SHOWING BREECH CLOSED.

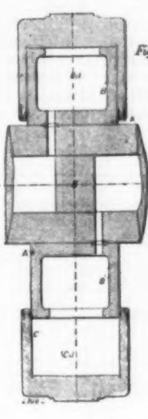
THE ELSWICK 4 IN. AND 4·7 IN. QUICK-FIRING GUNS.

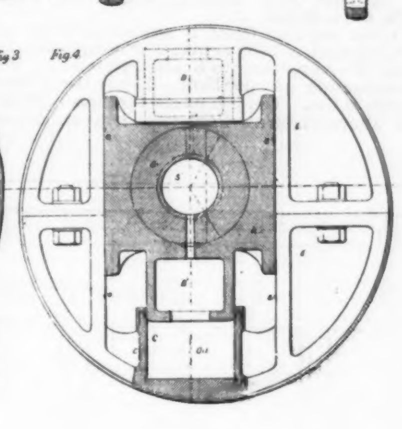
the "link gear" are fulfilled, but with one-fifth of the number of parts, and giving a much more correct distribution of steam.

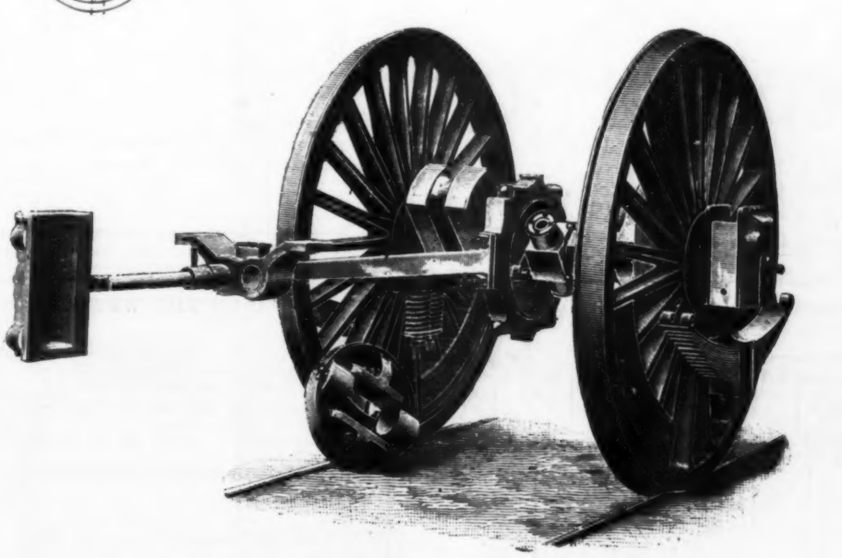
Referring now to the engravings (Fig. 4), A is a cast iron or steel square block, fitted on the shaft, S, in the position usually occupied by the two eccentrics in link gear. This block has cast with it, on opposite sides, two small rams, B B', the other two sides of the block being planed at the surfaces, *a a*, to receive the eccentric, E, which is bolted together centrally in the usual way, having the surfaces, *e e*, planed to slide on the surfaces, *a a*, of the square block, A. In the eccentric,











JOY'S FLUID PRESSURE REVERSING GEAR.

and forming part of it, are cast two small cylinders, C C', into which the two rams, B B', fit.

We have now the eccentric mounted on a square on the shaft and free, while moving round with and driven by it, to be slid from side to side on that square; the direction of that sliding action being on the center line, arranged to be at right angles across the center line of the crank and connecting rods, when at extreme ends of the stroke and within the center line of the crankshaft, toward the crankpins, if inside steam lap is to be used, as is usual with piston valves, or outside that point if outside lap is required; the movement given to the valve being equally correct either way, and whether for forward or for backward going; each extreme position being for forward or backward going, the central position being mid gear; and any intermediate position giving any variety of cut-off. The movement of the eccentric in either direction and its control in any positon is effected by forcing in a non-elastic fluid at a pressure at either end of the crankshaft, which in this case, as for warships, is already hollow, as at S' (or in ordinary shafts it is drilled).

The fluid is put in motion in either direction by a steam cylinder, M (Fig. 1), operating on the piston of a cylinder, N, which serves as a reservoir for the fluid, transmitting the power through the pipes, P P', for forward going and on through the crankshaft, and so into the small cylinder in the nearest eccentric, suitable for carrying it over in the direction for forward gear, while the fluid in the opposite cylinder in that eccentric is passed on to the next following eccentric to move it over; and so on till the receding fluid finds its way by the pipes, P P', to the opposite end of the fluid cylinder, N; of course, the reverse action of the steam cylinder again returns the eccentrics to the original position.

Thus the positions of the eccentrics for forward or backward motion are secured without the intervention of any mechanical combination in the form of links, levers, screws, etc., liable to wear out or break down. And by the simple arrestation of the movement of the fluid, the eccentrics are maintained in any position, so giving any required point of "cut-off." The cylinder, N, is made of a sufficient capacity to contain a margin of about 25 per cent. more fluid than is required to fill all the eccentrics, pipes and other channels, etc., to be able to follow up the eccentrics, if required.

From this description the general principles of the system will be easily understood; and to those familiar with the designing of fluid-pressure machinery it is well known how, working through the medium of a non-elastic fluid for the transmission of power, such machinery is peculiarly sensitive to exact and certain control.

Thus this gear lends itself specially to all the adjustments required in a triple-expansion engine at sea; and, though it would have made the paper far too long to go into any of the details for effecting these adjustments, it would not be complete without merely naming some of these. Thus, that while the engine is running, all the three cylinders may be "linked" up simultaneously, or each may be independently adjusted; and that, while so variously adjusted, all may at once be thrown over into full gear, either forward or backward, without any manipulation of screws, as in the reversing levers of link gear.

All these adjustments are effected by differentiating the amount of fluid between the two cylinders in any eccentric; and, as in the Maxim gun, the recoil of the shot is made available to discharge the exploded cartridge, supply a new one and fire it, so the tendency of each eccentric, when working expansively, to slip over into full gear is employed, by acting on a small valve in the eccentric by the motion of the engine, so allowing the fluid to change sides, under pressure of the tendency, to the amount for setting the point of "cut-off" required, when it may be locked in that position also by the fluid pressure.

There is also provision made in the arrangements of the valves and pumping gear of the fluid cylinder or reservoir for reversing by hand when the steam is not on, or for refilling any of the pipes, channels or eccentric cylinders; and, finally, this part of the gear may be linked up as a governor, employing the inertia of the fluid in motion and under pressure to move the valve of the steam reversing cylinder toward mid gear on the smallest increase of the speed of the engine, so linking up all three cylinders in that direction to the required amount to check the speed of the engine. The machinery for all these adjustments is of a small and very simple character and of a class in which I have had large experience; and for all details there are ample precedents.

The advantages of the gear are—first, its simplicity of construction and fewness of parts, all such parts also being of ordinary form commonly in use, with the further advantage that, as only one eccentric is required for each valve, that may be made of double strength and surface, if desired.

Resulting from the above, the gear is very much less costly than link or any other gear, fully by half, as not only are there fewer parts, but none of these are complicated and costly forgings, as motive links, requiring difficult and expensive tooling; almost all the work consisting of simple castings in steel or iron and requiring chiefly boring and turning, the easiest and least costly operations in the tool shop. Then, having far fewer parts, it is less liable to break down; less attention and lubrication are required. Indeed, if wished, the whole of the lubrication on the crankshaft may be performed by the motive fluid itself (using oil), which may be recuperated automatically by the engine itself while in motion.

Again, it fits into the position of the link gear exactly, requiring no alteration whatever in the ordinary type of engine. Further, the newly designed part connected with the fluid pressure machinery may entirely break down without destroying the efficiency of the engine, which will still continue her voyage in full forward gear; for, if the engine is working expansively, the only result of the entire failure of the fluid gear is to allow the engine to slip into full forward gear, while, if working in full gear, there is no strain at all upon that part of the machinery.

And now, though this gear was originally and specially designed for marine engines, it is really a valve gear of general application for any class of steam engines and suitable to be employed wherever link gear may be used. Therefore, in selecting an engine on which to test its efficiency, I chose a locomotive, as offering opportunities for the most crucial tests to be carried out in the shortest time, as also other important advantages; as the greater ease with which experiments can be conducted and recorded on land than at sea, the freer access to the machinery by numbers, whether of workmen or of those wishing to inspect, as compared with a crowded engine room at sea. Alterations, repairs or additions may be readily made, variations in loads or in speeds may be effected, continuous working may be maintained, independent of weather or tide; but, most of all, a much more crucial and varied series of tests may be crowded into a very much shorter time than with engines at sea. Thus the engine fitted with this gear has been at work about a year, and during that time has had the reversing gear as frequently manipulated, shifted from forward to backward going, and changed about to all degrees of expansion as could have occurred in a channel steamer in six or seven years, or as in an ocean-going steamer in quite an unknown time.

With regard to the newly required constructive details, several points of interest arose and had to be dealt with. One or two only I will name. Thus it was objected that, at the point where the stationary fluid in the pipes at either end of the crankshaft met that which was revolving rapidly in the shaft, heat would probably be generated. This never occurred, but its possibility was met by enlarging the spaces or channels at that point, so allowing room for the stationary particles to interchange gradually among those rotating rapidly.

Again it was urged that, as the fluid had to sustain the reciprocating effort of pulling and pushing the valve, a throbbing or pulsating action would be generated. This never has existed, for, whether running slowly or very fast, and even with a considerable amount of air in the pipes, the whole gear runs with the solidity of a gear of steel with no intervening fluid. The most suitable fluid to be employed has also been

subjected to investigation, and if frost is not feared and lubrication is not contemplated, then any non-elastic fluid will do; but probably one of oil and nine of water will be found most convenient and cheap.

For packings I, of course, used the ordinary leather cap packings, of which I have had very satisfactory experience under pressures up to 5,000 lb. per square inch. The practice in the case of the Westinghouse brake pointed in the same direction; but, thinking it well to be independent of organic material, I have been trying to get at a figure in which to employ metal, and some of the results are on the table.

Now it only remains for me to refer you to models, drawings and photographs on the walls and on the table—among these, to the original machine on which I satisfied myself that the broad principle upon which I proposed to work was practicable, and cards of diagrams taken from it giving the valve stroke—and also to inform you that the locomotive on which this gear has been tested will be at the Victoria Station of the London, Brighton and South Coast Railway.

THE LUHRIG GAS MOTOR CAR.

ALL gas manufacturers have the greatest interest in attentively watching the tentatives made to apply gas motors to tram cars, not only because it is a question of the prospect of an increase in the consumption of gas, but especially because such application would have the effect of greatly increasing a day consumption that would be assured for the whole course of the year, and would more completely and more regularly utilize the *materiel* of our gas works.

Mr. Kemper, in a communication made to the congress of Dresden, naturally begins by analyzing the different systems now in use:

Traction by horses renders our streets unhealthful, and, besides, the general expenses of maintenance and interest on the investment are very heavy. Steam tram cars are scarcely practical in the interior of cities; the exploitation of compressed air tram cars is very costly, even where natural forces are at one's disposal; and among the electric tramways, those operated by the trolley system offer decided advantages from a practical and economic point of view, but, as an offset, they present serious inconveniences, from an æsthetical standpoint, with their cumbersome and unsightly poles along the sidewalks.

These points stated, Mr. Kemper passes to gas motor tram cars. These cars carry their supply of compressed coal gas stored in cylindrical receivers about 11 in. in diameter and of a capacity of from 55 to 90 cubic ft. The same regulators employed by railways for lighting by the Pintsch system are used for the discharge in gas motor tram cars.

The gas can be taken from any point of the pipe line, provided that the section of the conduit is large enough. It is necessary to establish there only a small station in which the compression of the gas and the filling of the receivers can be effected. According to the length of the road and the number of cars running upon it, there should e established one or more of

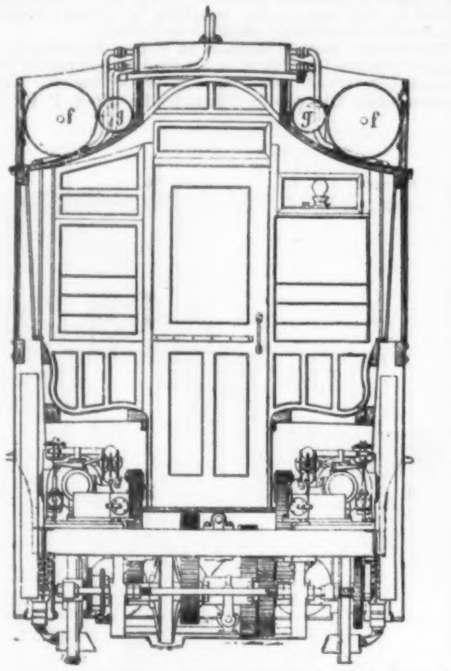


FIG. 3.—TRANSVERSE SECTION THROUGH THE AXIS OF THE DRIVING SHAFT.

such stations, each costing, everything included, from $2,000 to $3,000.

In these stations there is a stationary gas motor which, through a belt, actuates a compressor that is capable of compressing to 8 atmospheres 210 cubic ft. of illuminating gas per hour. The section of the suction pipe is 4 in. The gas passes through a 500 burner meter, above which are fixed two Scrabetz apparatus for preventing the fluctuation of the gas. The apparatus very advantageously replace the rubber pockets employed in gas motors. From the compressor the gas flows to the reservoirs, which have a capacity sufficient to furnish two cars with gas at six atmospheres.

The gas motor of the compressing station consumes about 8 per cent. of the gas to be compressed. It is possible to compress 350 cubic ft. of gas per horse hour.

There are at present two systems of gas motor tram cars in operation, the Guillieron & Amrein system and the Luhrig system. It is the latter that forms the principal object of Mr. Kemper's communication.

The Luhrig establishment is constructing two types of gas motor tram cars. We represent herewith the large model, which is capable of accommodating 16 persons in the interior and 11 upon the two platforms, which makes 29 with the engineer and conductor, that is to say, more than an ordinary one horse tram car is capable of containing.

The motion is given by two twin 7 h. p. engines placed lengthwise under the seats, in such a way that the flywheels are placed at the exterior and behind the backs of the seats. The motors are constructed especially for this object by the Dentz works, and, in order to gain space widthwise, the cylinders of the motors are placed opposite each other.

The two motors are capable of acting upon the driving shaft either together or separately. It is possible to give the motors three velocities by means of levers maneuvered by pedals—a velocity of 100 revolutions per minute for working to no effect during stoppages, and one of 200 revolutions and one of 240.

The cold water reservoirs are placed upon the roof. The gas reservoirs are five in number—four under the floor and one upon the roof. The pressure of the gas is reduced to from 1 to 1⅛ inches by a Pintsch dry regulator.

The products of combustion pass directly into a receptacle in which the noise of the exhaust is smothered, and thence to a condensing apparatus upon the roof, whence they make their exit into the open air without noise and nearly without odor.

On each side of the car there is a door with two leaves, and two small doors that prevent any detail of the machinery from being seen. When these doors are open, all parts of the motor and of the transmission are easily accessible. The specification of the Luhrig patent dwells especially upon this arrangement.

The change of speed is effected by pressing a pedal which acts upon a lever. The latter in turn acts upon the governor of the motor. The starting and stopping are effected by means of two hand levers that engage or disengage the toothed wheels that transmit the motion. A sudden stoppage is produced

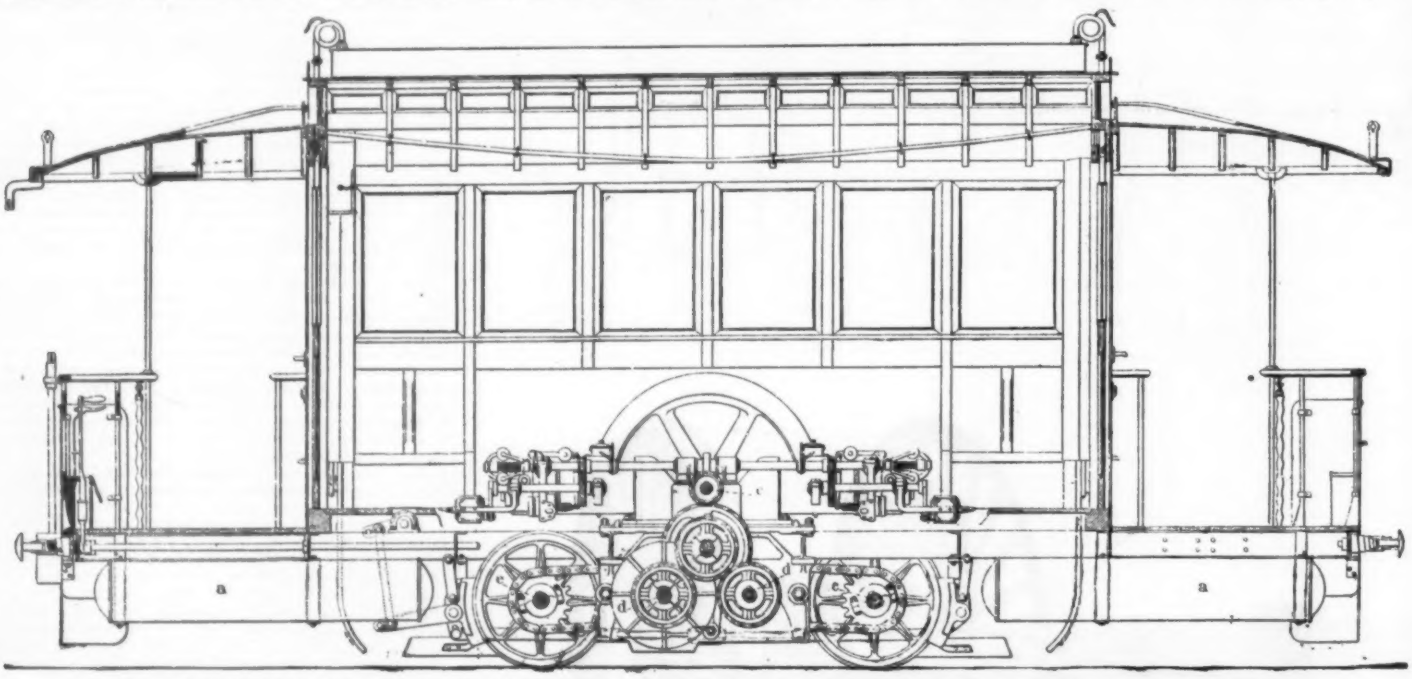


FIG. 1.—LATERAL ELEVATION—ARRANGEMENT OF THE MOTOR AND THE DRIVING GEAR OF THE WHEELS.

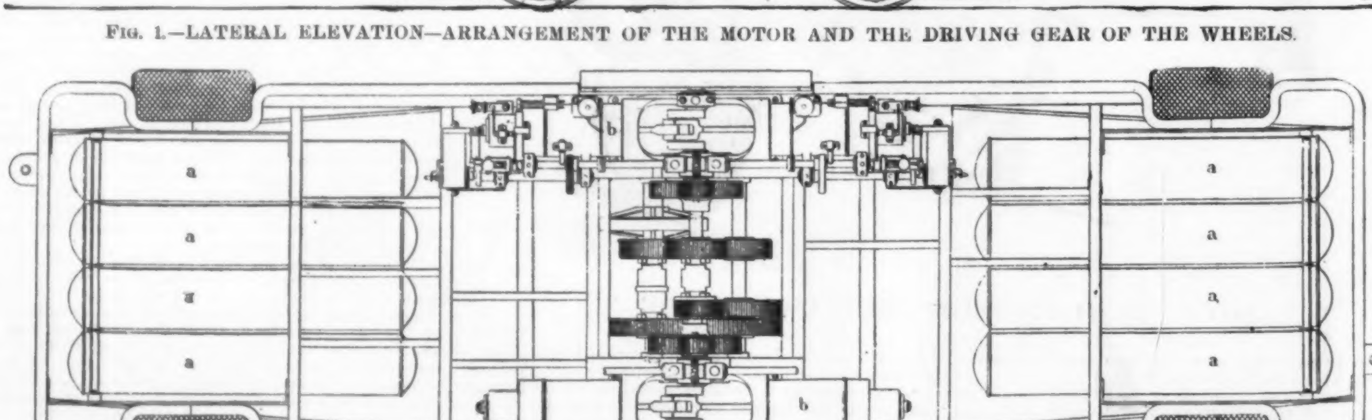


FIG. 2. PLAN.

a a, reser oirs of compressed gas; *b b*, two-cylinder gas motors; *c*, driving shaft; *d*, transmissions between the driving shafts and the wheels of the car; *e*, driving axles; *f*, cold water reservoirs; *g*, exhaust condenser.

LUHRIG'S GAS MOTOR TRAM CAR.

by means of a hand wheel that acts upon the brakes. These maneuvers are much simpler than they seem to be at first sight, and any new hand can learn them very quickly.

Externally, the car is scarcely distinguishable from an ordinary horse car. It has at the most a somewhat heavy appearance on account of the large door with two leaves that is placed on each side, and of the wide escutcheons that conceal the reservoirs on the roof.

This large sized car weighs, when empty, about 7½ tons, which would indicate for a complete load of 29 persons, of 150 pounds each, a weight of 9½ tons. In some experiments, the car, with a complete load and at a medium speed, easily ascended a gradient of half an inch to the foot.

Along a gradient of two inches to the foot, which is a very heavy one, and one rarely met with in cities, the speed of a car with a 14-horse motive power and a load of 9½ tons is 4·4 feet per second. The power absorbed by the transmissions is negligible, because the Dentz motors are capable, as a general rule, of developing 10 per cent. more than their normal power. This speed of 4·4 feet is that of a pedestrian. Such gradients present themselves only on short lines, and so reduced a speed has no serious inconvenience. It would be important, however, if the line were lengthy, and it would then be necessary to employ the car that we have just described only in cities where the gradients are moderate.

For the exploitation of roads with heavy gradients, the Luhrig establishment has constructed a smaller car with a single 10 horse power motor, and in which the two-cylinder engine is placed under one of the seats, while the cold water reservoir, the receptacle for expelled gases, etc., are placed under the other seat. According to Mr. Luhrig, this car weighs, empty, about 4½ tons, and is consequently no heavier than one run by an electric motor. It is capable of accommodating 22 persons, and with a complete load the total weight would therefore be about 6 tons. According to calculation, it would be able to ascend a gradient of 2 inches with a speed of 5 feet per second—that is to say, with half of its normal speed. This is already a great progress, but it is still far from what may be attained with electric tram cars. However, the studies that are being pursued will permit of sensibly diminishing the weight so as to make it possible to attain the normal speed under all circumstances. The cost of these cars is not well determined, and will not be until the orders received shall permit of a regular manufacture. The builders believe that it will be possible to sell the large model at $4,450 and the small one at $3,500.

The consumption of the gas may be ascertained at any moment from a manometer placed in the interior of the car. The large car has receivers of a total capacity of 65 cubic feet. If the manometer indicates that the pressure of the gas has lowered by two atmospheres, for example, during the trip, it will at once be seen that the consumption of gas during the trip has been sensibly $2 \times 65 = 130$ cubic feet. Mr. Kemper in this manner found that the large car, with a mean load of from 10 to 12 passengers, consumed, per car and per mile, 43 cubic feet of gas on one occasion and 45 on another. As these observations were made while the car was new and the transmissions consequently still gave too much friction, it must be admitted that in a regular exploitation the consumption should fall below 40 cubic feet. The small, single motor car consumes less than 35 cubic feet, according to the engineers of the Luhrig establishment. It may, therefore, be said that, in admitting into the calculations of the expenses of exploitation a mean consumption of 40 cubic feet per car and per mile, we have not taken too low a figure.—*Annales Industrielles.*

TRANSMISSION OF POWER BY FRICTION PULLEYS.

By G. D. HISCOX, M.E.

MUCH apprehension exists among our practical mechanics and inventors as to the applicability and efficiency of this little understood method of transmission and direction of power in the great variety of machinery to which it is applicable. We are often asked what the efficiency of this method is in comparison with belts and gearing, as well also of the various materials that can be run in contact for this purpose. There seems to be a largely increasing desire to bring the running parts of machinery into a more compact form and less noisy than the geared system allows.

For this purpose we illustrate some of the many forms and combinations of power and speed possible in this line, together with the efficiencies that may be expected from the various materials used as friction surfaces.

The value of friction with contact pulleys is fully equal to leather and rubber belting of 180 degrees lap, when the same material is in contact in both cases; the difference being the loss from unsymmetrical cones and curved surfaces, which produce a constant angular slip. In these forms there are mitigating circumstances which make their use necessary in order to accomplish specific results, and in which the speed relation of the two pulleys should be increased to compensate for the slip.

Fig. 1 is a type of the cylindrical-faced pulley sys-

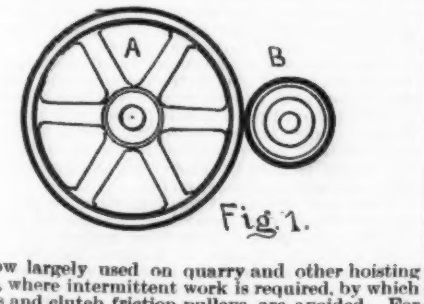


Fig. 1.

tem now largely used on quarry and other hoisting engines, where intermittent work is required, by which clutches and clutch friction pulleys are avoided. For high speeds, as for spindles, circular saws and dynamos, its compact and efficient transmission is bringing this system into high repute.

For any speed a leather-faced driver, A, with cast iron driven pulley or pinion, B, gives an efficiency of from 32 to 34 per cent. of the pressure on the faces in contact in stress of power.

Thus a pair of friction pulleys running with a speed of 1,000 feet per minute at a maximum pressure of 100 pounds per inch in width of face contact will have a working stress of 34 pounds per inch, or 34,000 foot pounds, or say one horse power per inch of face.

The friction of a wood pulley driver on a cast iron driven pulley is claimed to be as high as 50 per cent. power strain in units of the compression, and as wooden pulleys are now largely represented in the mill trade, this material is a most convenient application, affording the highest efficiency.

The propriety of using the wooden or leather faced wheel as the driver is apparent, especially with high speeds, as in starting, the iron pulley, if a driver, is liable to cut grooves across the soft wooden or leather faces.

The bevel and miter form of friction gearing, Fig. 2,

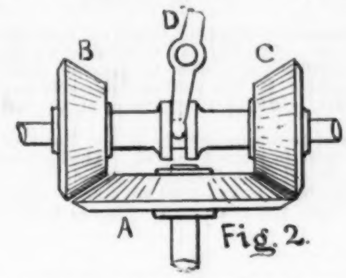


Fig. 2.

is largely in use for driving centrifugal driers and extractors, reversing speeds for wood moulding machines, for which purpose this form of power has been adopted by our most reputable woodworking machinists. Its frictional coefficient, on account of imperfect contact, is not quite as great as with cylindrical-faced pulleys, but may be safely estimated at 30 per cent. of the compression; the power transmitted otherwise at the same ratio of face contact as with cylindrical pulleys.

The old style V gear, Fig. 3, is still in use for heavy

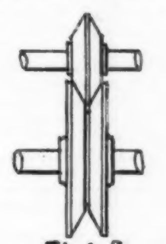


Fig. 3

and rough work in quarry and mill hoists and occasionally in machine shop practice. It is a power consumer. The angular form of the friction surfaces, 50 to 60 degrees, tends to increase its power stress in percentage of its compression. The loss by angular face friction more than compensates for its grooved form of contact.

The contact velocity in computing for power should be taken at the smallest contact diameter of the driving pulley; the circumferential difference between the inner and outer contact being lost velocity.

The multiple groove friction gear, Fig. 4, was a great

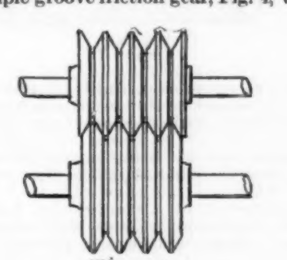


Fig. 4.

improvement over the single large groove, by the amount of its extension contact. This form being almost wholly confined to metallic contact, its coefficiency cannot be relied upon for more than 30 per cent. of the contact compression.

The grooved form of friction gear of any angle and number of grooves is subject to severe wear by the angular rubbing surface causing the outer portion of the driving pulley and the inner portion of the driven

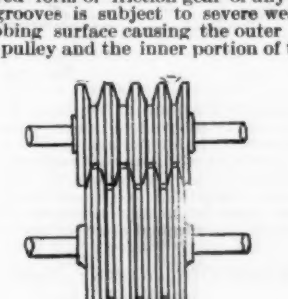


Fig. 5.

pulley to wear faster than the opposite portions of the friction surface. and lessening the area of contact; thus showing the increased value of small grooves for efficiency in wear, and better, finally, by eliminating the grooves in favor of a plain surface.

The Van Haagen type of grooved gear was introduced for its holding efficiency in percentage of the contact pressure.

Its angle of contact, about 15° with the plane of revolution, giving a firmer grip, with an efficiency of about 60 per cent. of the contact compression, shows excellent results for some purposes; but its angular contact friction and surface wear is largely increased over the shallow groove system.

This system for angular feed motion has been in use by some of our leading machine builders as illustrated in Fig. 6. It is not an easy gear to make,

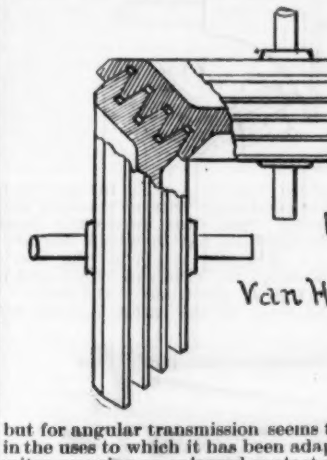


Fig. 6.

Van Haagen.

but for angular transmission seems to be very efficient in the uses to which it has been adapted, having by its miter grooving an enlarged contact and increased friction from its small angle, requiring but small compressive force for its assigned work. Its efficiency is greater than with the conditions in Fig. 5, having a possibility of 80 per cent.

The form of transmission of power in cross line shafting of small angle, Fig. 7, has a small traverse creepage

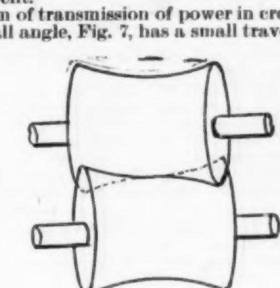


Fig. 7.

due to the angular contact of the concave faces of the pulleys. It may be used in place of skew gearing for light work. It is easily made of wood or leather disks for very small pulleys, or for larger ones the wooden pulleys found in trade may be concaved on their face to fit the position. Its efficiency for small angles is nearly equal to the cone pulleys, Fig. 2, or about 28 per cent. Fig. 8 represents one of the least objectionable

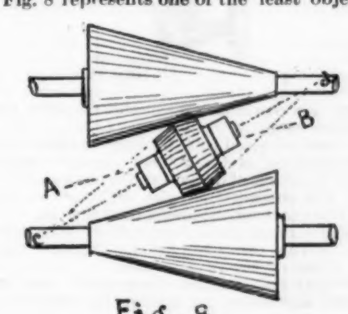


Fig. 8.

of the cone speed trains, the conveyor pulley being a double cone, with their conical apices exactly meeting the apices of the driving and driven cones, *c*, *d*, in the cut, and their line of movement for variable speeds parallel with the face of the driving and driven cones as shown by the dotted line, A, B, Fig. 8. This form of speed cone will transmit the same amount of power as a belt of the same width of contact surface and the same speed.

Fig. 9 illustrates two methods for variable speed from

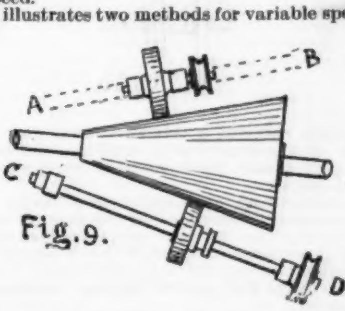


Fig. 9.

a cone driver. A traversing pulley and band wheel on a short shaft in a frame, traversing a bar, A, B, which may be made to rock by a lever to throw the driven pulley on or off the cone driver.

A convenient and simple device for running a sewing machine. This requires a lateral movement of the band which does not interfere with the proper running of the machine, when there is 2 or 3 ft. distance between centers.

On the opposite side of the last figure is represented the driven pulley, on a feathered shaft, *c*, *d*, moved by a sliding yoke with a fork on the hub, which

allows of a stationary point for the machine pulley. This should also have a rocking motion on a bar for starting and stopping.

A variable speed from a short concave driving cone, Fig. 10, in which the driven pulley moves along the

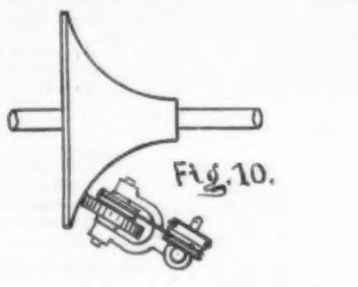


Fig. 10.

concave surface of the cone in a yoke turning on a movable center for producing friction pressure and starting and stopping. With this device the band may be direct to the machine, but in which the driving end will have a swinging motion as the speed changes, or may be arranged with two bands and a double groove wheel at the pivot end of the arm.

In Fig. 11 we have one of the latest devices for

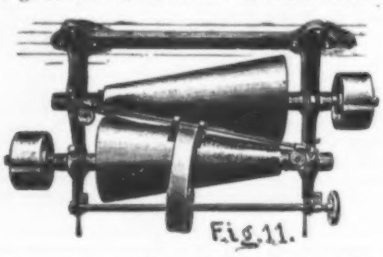


Fig. 11.

variable motion, and also for a steady speed from a variable speed power.

It consists of a pair of cones pressed closely together with a short belt running loosely between, guided by a shipper and lanyards for operating change of speed by hand, or attached to a governor for automatically controlling a uniform speed from an unsteady power. The speed variations are thus made easier than with the ordinary belt shipper. A complete device which can be placed as readily as a common hanger. It is manufactured by the Evans Friction Cone Co., Boston, Mass.

The friction disk, Fig. 12, is one of several simi-


Fig. 12.

lar devices for variable speed and variable power in their inverse ratio.

It has been adopted by a leading manufacturer for light drill presses, and is a most sensitive application for the needs of small drills, by starting the drill spindle with the pressure on the drill and varying the speed to the exact requirement of the work.

The coefficient of driving power is estimated at 30 per cent. of the pressure, falling slightly below the value of a belt of the same width.

The Wright friction disks, largely in use for driving sewing machines by power, in which A is the

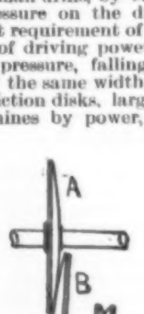


Fig. 13.

power shaft, carrying a spherical-faced disk, and B a similar disk mounted on a small countershaft with a band pulley and band running vertically to the sewing machine.

The countershaft is mounted in a frame pivoted beneath at the half distance of the contact surfaces, and with the two motions necessary for operating speed and pressure, controlled by a single treadle that produces contact for slow motion and by further pressure swings the curved friction surfaces for a higher speed.

Variable motion in parallel lines, of which Fig. 14 is a type, where A and B are friction disks on parallel shafts of small central distance, and *c*, *d* a traverse shaft carrying a narrow pulley. In this system the disks may have a fixed compression and the transmission pulley run on and off from one of the disks for starting and stopping.

A modification of this system is in use for driving centrifugal driers by making both disks the drivers on two central lined shafts, and the vertical spindle, *c*, *d*, the driven shaft of the centrifugal machine. By concaving the driving disks at their centers and with the small pulley traversing on the feathered shaft, *c*, *d*, the speed of the centrifugal may be controlled, checked and stopped by the movement of the spindle pulley to the center of the driving disks, where the concavity in the disks releases it from friction.

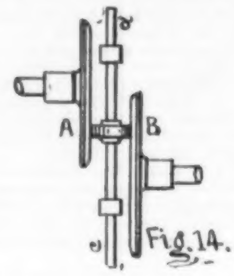


Fig. 14.

The destructive vibration which the cone-driven centrifugals are subject to may be avoided by this system of transmitting the power to opposite sides of the driven pulley. By this method the coefficient of friction power is doubled by virtue of the double contact.

The drop press now stands at the head of all the devices used in forging metals. The accuracy of its work in the art of moulding articles of iron and steel, by a single blow, is a marked advance on the processes of but a very few years past. Fig. 15 represents the


Fig. 15.

modern method of handling the drop hammer, which is attached to an oak board between two revolving rollers or pulleys, one of which has a release grip by the movement of an eccentric shaft actuated by a lever and lanyard or rod.

So well adjusted are the moving parts that any desired blow may be given. Its simplicity makes its duplication available to any extent in manufacturing the thousand varieties of articles of hardware and the parts of delicate machinery.

The contact force being double, its efficiency for lifting is about 60 per cent. of its contact pressure.

Frictional rectilinear motion from the angular position of a sheave or pulley rolling on a revolving barrel or long cylinder, Fig. 16, is a type of the Judson sys-

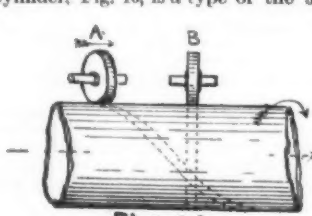


Fig. 16.

tem of railway propulsion, the frictional efficiency of which was increased by the use of small trucks carrying several pulleys with pressure from the weight of the car.

The speed of the car being controlled by swiveling the truck through about 45°, as in the positions at A and B, in the cut.

The combination of a compression pulley, for increasing the traction of a short belt, is shown in Fig. 17. It gives a large coefficient of power in proportion

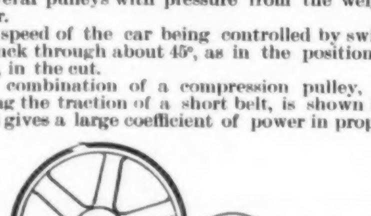


Fig. 17.

to the tension on the journal bearings, and which may be almost entirely relieved of undue strain by a judicious proportion of the friction pulley to the driving and driven pulleys, and thus obtain from a single thin belt more than double the duty of the belt alone. For dynamos and other high speed machines, the heating of journals may be nearly eliminated by the proper adjustment of this method of speed transmission.

GOLDSMITHS' WORK: PAST AND PRESENT.*

By Mrs. PHILIP NEWMAN.

THE subject on which I have been honored by being asked to speak to-night is a very large one, and one very near to my heart. It embraces so many points, its history and theory have been written about, spoken about, divided and subdivided under so many heads, that historically and theoretically there is little that is new to say; but, curiously enough, since the monk Theophilus wrote his famous treatise in the eleventh century, little has been written on the practical side of the question; and, as it is before the applied art section of this great institution I have the pleasure to appear, I shall venture to let my paper take a more technical form than would be desirable for a general audience.

Alloying, melting, working, coloring and polishing gold have been my chief studies and occupation for over 25 years; for long years before that I modeled, designed and drew for goldsmiths' work; and though I should easily be beaten in the use of a blowpipe, and find it a little difficult to arrange very fine grains with a pallion of solder, yet I think there is no calculation for alloy or mixing of the precious metals, no pot for melting skittle, plumbago, or other kind, no tool for working, no direction of h at, whether a sharp point of flame, a blunt one, or an all-over blast, with which I have not a perfect acquaintance. The different metals necessary to mix with the gold to obtain the softest and richest effects for enameling, or the different qualities of solder best to use for various kinds of work, wet or dry color, are all familiar to me; and this everyday experience of mine leads me to hope that I may be able to interest you in the working of the gold and show how it was done in former times and how it is done now.

There seems to be a consensus of opinion that gold was the first metal discovered. It is beautiful in color, was found in rivers, in sand and on the surface, while other metals had to be dug from the bowels of the earth. It is so attractive in appearance, the most untutored savage would observe its beauty; and it was universally known.

Goldsmiths, that is, men who work in gold, are supposed to have been the first workers in metal, and to have been the pioneers in all the manual arts.

There is a popular idea that gold can only be fashioned by the aid of heat, but, as I had occasion to point out in a lecture I gave last March before the Society for the Encouragement of the Fine Arts, much of the ancient work was made without the application of heat at all.

In every small treatise, in whatever language it may be written, on our subject, one quotation from an old author is always given, and as there is no better way of expressing the qualities of gold, I will repeat it: "Gold is very ductile, a spreading and oily metal;" and to use an old workshop term, "it is very kind." It can be hammered, drawn as wire and fashioned without heat; and it is almost the only metal which is ductile enough for this without the aid of steam power.

If we examine many of the oldest specimens, we shall find that they have been worked cold, beaten and twisted into shape by sheer force, which is, literally, an application of heat, but it is not so technically.

There is a tradition that Tubal Cain was the first to make gold leaf. Anyhow, the art of beating gold is so old that, like the early history of most things, "its origin is lost in obscurity." But, as every handbook will tell you, Homer and Pliny both refer to it. Homer also mentions and describes a blast furnace with 20 crucibles, and melting pots have been found in many places in Egypt.

It is quite possible to have hammered together the little particles of gold found on the surface of the earth and elsewhere, and made them into rough utensils or ornaments without melting the gold at all; but probably as soon as furnaces and melting pots were known, the gold was melted and run into a rude skillet before the hammering process began.

It would take up too much time to mention the various places where gold was found in bygone times, or to enumerate the usual sources from whence gold is obtained now. Suffice it, for our purpose, to admit that the very first thing a goldsmith needs is pure gold; not that pure gold can be worked, for it cannot. No really chemically pure gold was ever worked, or ever could be. Many ornaments of refined gold are mentioned by old writers, but in no instance have I found any record of any antique made of pure gold. Purity in this metal is represented by the number 24; standard gold has 22 parts pure to 2 parts of alloy; 18 carat gold has 18 parts pure to 6 parts of alloy. French gold, called 18 carats fine, is not so pure as the 18 carat gold used here; it only assays to 17 3¾, or a quarter of a grain worse than would pass Goldsmiths' Hall as 18 carat. The French gold is alloyed with copper, which gives it the reddish tinge. We alloy with both silver and copper, and no point has been more discussed and quarreled over than the exact amount of silver and copper necessary to make the best alloy. It is only 6 parts in 24—not much to wrangle about, you will say.

I will not attempt to give you all the formulæ, or to decide which is best, only, like everybody else, in one particular proportion of silver and gold I believe, and in no other; even when 22 carat gold is to be prepared, the 2 parts of alloy are matters for much comment and dispute. I know two really estimable men who quarreled bitterly on this question, the one said that of the two parts one should be silver and the other copper, while the other stoutly maintained that the proper proportion was one and a half copper and half silver.

Well, the gold being alloyed to 22, 18, 15, 12, 9 carat, or even a lower quantity of gold, it is put into what is called a pot and melted on a furnace. This furnace can be heated by gas, by charcoal, or by coke; it could be by electricity, but the application is not sufficiently perfected to be used for a goldsmith's furnace yet; however, it will, I hope, be so soon.

When the gold is absolutely fused—and the greater the proportion of gold in the mixture, the greater the heat required to fuse it—it is poured into a mould called a skillet, and allowed to cool; when cold it is ready for flatting, which is done by rolling it between two heavy steel rollers. It depends on the intended use how thin the metal is rolled. There are gauges for this, like those for wire and sheet metal.

If the gold is wanted for gem rings, it is left thick and cut with shears into slips. I mean for good work. For common work done in Birmingham and Sheffield (and, I am sorry to say, in London, too), the settings for the stones are stamped out by machinery, and the claws bent over the stones, instead of, as in the best work, the claws being cut to the stone. The goldsmith will, for himself, further flat the gold in small mills, if it be necessary for his work. He will also fuse small

* A lecture delivered before the Society of Arts, London, February 27, 1894. From the *Journal*.

pieces or cuttings into the shape he desires, on what he would call "a coal," really a long piece of charcoal hollowed in the center, for the very old terms are still used in work rooms (charcoal was called "coal" long before "sea coal" was burned in the Chapter House, at Westminster, where the first fire was made of what we now call coal, of which we have any record; but this by the way).

Having arranged his gold in the rough, the workman proceeds to hammer it more nearly into the required shape, if it be for a ring with stones in it. After he has fused a thick mass for the head, he hammers a long straight piece (cold work, you see), then with his pliers he bends it round to get it roughly into shape, then he files the inside to get it smooth enough to make it the desired size to fit the finger, it is then filed and scaupered into shape, carved and clawed. The ring is soldered together at the back, it is polished with sandpaper, with "water air stones," which look very much like slate pencils, and with hard wood. The little claws are "threaded out," *i. e.*, polished with whitey brown thread, on which a little rouge has been rubbed. So far, all work goes through these processes, whether it is to be finished bright or colored. The last thing done is setting the stones.

Now, you will perceive that the gold was alloyed and melted into an ingot; so far heat was used, but for the flatting no fire is necessary. Tradition—and all tradition has a basis of truth—says the gold the ancients made the ornaments for the dead from was beaten into the thin plates from which the wreaths, etc., were cut between thin layers of leather and beaten with a very heavy hammer. Gold beaters now beat their gold between thin leaves of vellum. The thin gold used by the ancients for their funeral ornaments was of the same degree of fineness as that beaten now, which has about one part alloy, either silver or copper, to twenty parts of pure gold. The alloy diminishes the malleability, so the inducement is only small to deteriorate the quality, for gold leaf is sold by size and not by weight.

Now, the gold is cast into oblong ingots, about $\frac{3}{4}$ of an inch thick and wide, and each weighing about 2 ounces; this is flattened into a ribbon about $\frac{1}{100}$ part of an inch thick, then annealed or softened by heat and cut into pieces about an inch square; 150 of these are put between vellum, each piece of gold in the center of a square of vellum; another and another added, until a pile of 150 is made. This pile is inclosed in a double parchment case and beaten with a 16 pound hammer. The elasticity of the packet lightens the labor, as the hammer rebounds with each blow. The beating is repeated until the inch pieces are spread out to four-inch squares; they are then taken out, cut into four pieces each, placed this time between gold beaters' skin, and hammered as before, but this time with a lighter hammer. They are again quartered, and again hammered, thus producing 2,400 leaves, having an area of nearly 200 times that of the ribbon, and a thickness of $\frac{1}{200000}$ of an inch.

The soldering of the ancients was something very marvelous. Castellani is of opinion that, so far as gold work was concerned, they were better chemists than we are, and used solvents with which we are unacquainted.

The delicate grain work with which the Etruscan covered large surfaces is not easy to imitate. Here is a little piece roughly done, as an illustration; but there are few men who can do it now.

For a long while after the Etruscan gold work came to light, it was found impossible to copy the color of the gold, but now we can get it exactly by putting the proper proportion of common salt, saltpeter and alum in a flat-bottomed pot with distilled water, and heating to 212° Fah. This mixture is not pretty to look at, for it boils up a pale, sickly, greenish color.

The gold work to be colored should not be of less than 18 carats fine. It is hung from a platina ring with either platina wires or horsehair; there should be plenty of it, for the greater the amount of gold to be colored, the better the color of each article. The work, having been properly cleaned, is dipped into the boiling mixture, taken out, dipped into clean boiling water, dipped into the color pot again, again washed in hot water: about the third dip the rich bloom of color comes. Much more washing is still necessary before the work is ready to dry in hot boxwood dust, after which it is scratch-brushed. This is a scratch brush: the hole in the center fits on to the mandrel of a foot lathe, the article to be finished is held against the revolving brush in the hands of the workman. Now, nothing is so good to feed the scratch brush with as *beer*; this drops on the revolving brush from a little hole in a small tub fixed over the lathe, so that the beer drips on the brush as it revolves.

If this scratch-brushing is done by a clever operator, 18 carat gold has the beautiful bloom of the best Etruscan work; this is the very reverse process of gilding, for in gilding pure gold is added to and spread over the surface, while, in coloring, the alloy is eaten from the surface, leaving only pure gold visible. We know that the Japanese derive some of their ideas from the most crystallized of all old time peoples—the Chinese. Shall we ever have a more intimate acquaintance with their inner life and their old tradition, and find out whether the Japanese "pickles," as their coloring mixtures are sometimes called, are made from early traditions of the craft—traditions of the knowledge emanating from the Hindoo Koosh, but lost lore to European nations? As to the processes, by which the result was obtained in the old work, we have little to aid us; but we may safely say that whenever the work was done, in prehistoric times, in Egypt, in Assyria, in the cities of Italy occupied by the Etruscans, in Greece, in Rome, or nearer our own time, in Florence, it was not the working that was so very different from our own; it was the almost intuitive feeling for art that made the gulf between the goldsmiths' work in the past and to-day.

In very early times mechanical aids to repetition were adopted; the Greeks used dies for the little amphoræ they were so fond of hanging round their necklaces; no doubt, also, they made cutters for the pateræ so often seen in Greek and Græco-Etruscan work. I do not suppose they had any better equivalent for a monkey press than a sledge-hammer, but they had that. Yes; the old craftsmen beat, flatted and annealed their gold; they drew wire, they twisted it, they screwed it, they did *repoussé* work, they engraved the most beautiful intaglii on their gold rings; they knew how to prepare their work for the inlaying of stones, of which enameling was only an imitation, and in the earliest times they understood Cloisonné and Champlevé enamels.

At the present time all these things are done, but we do not often have artists to make the dies, and we depend too much on the dies; it is the curse of cheapness that spoils our work. Now, necklaces, brooches, bracelets, are made by the dozen, all alike. It spoils the work, and it spoils the workers, for instead of a man being able to make all usual trinkets right through himself, it is found cheaper for a foreman to give so many articles, all to be alike, to one man, who takes so many boys under him. These boys are only taught to do one portion of the work, some only learning to make snaps, others only joints, others only tongues and catches. In after years what is to become of these lads? The men who teach them can only make one thing; a broochmaker can only make brooches, and so on, and of the separate parts of that thing he teaches so many boys to make one part only; not one of them could put them together from anything taught in their factory, and but few lads have the wish or the application to learn more than they are taught. No, it was a better time when the old system of apprenticeship prevailed, and it was to the masters' interest to teach a boy to be a thorough good workman. When the goldsmiths who have been apprenticed are all dead and gone, where will the craft be then? The boys "taken on" will not be of any use, indeed, many of them now finding it impossible to get their bread with the knowledge they have acquired, go as soldiers, so the little they have learned is lost.

If technical schools would only supplement proper apprenticeships instead of attempting to be a substitute for them, they would do much good. Reading all about an art for a year is not so useful as working with others who know and exercise it for a month. Practice is necessary, has always been necessary, and will always be so. There is no art, craft or trade where constant practice is so necessary as that of a goldsmith. I know of several goldsmiths now whose technical work is quite equal to that of the best periods, but they have not only served their time, but have lost no opportunity since their apprenticeship expired of learning more about their work. Such goldsmiths are becoming more scarce every year.

In old times, in all ages and in all places there were two separate and quite distinct branches of goldsmiths' work. In the one case, the work done for the temples in honor of the cult of the people; in the other, for the houses of their chiefs and kings and for the adornment of their women; but it seldom happened, until at any rate comparatively recent times, that the secular work was done by the same craftsman as the work for religious purposes.

In the early Christian times there was little sacred art at all; the sect was too poor and despised; but, as Christianity gained noble and rich converts and the church became a power, it was only natural that their places of worship should become more magnificent than the heathen temples had been; and that much of the gold and silver of the temples should be melted up and remodeled for the service of the church.

How far back guilds of workers in gold can be traced I am sorry I cannot tell you, but we must suppose that the "Aurifices" of Rome formed a sort of corporation, for they erected a little triumphal arch in honor of Septimius Severus in the "Velabrum;" this arch does not bear any characteristic mark of goldsmiths or their work.

In Rome I have seen ancient inscriptions bearing these words: "Aurifex Aug.," "Aurifex Augustæ," "Aurifex Tib: Cæsaris," "Aurifex Liviæ," etc. The inscriptions prove that in and after the times of Augustus and Livia, emperors and empresses had goldsmiths in title attached to their service; similar inscriptions to these have been found in Britain, I believe.

The Gallic people have long traditions as goldsmiths, for records remain of goldsmiths in Limoges before the invasion of Julius Cæsar. The name of only one Gallo-Roman goldsmith has been preserved; it was Maburnius; he is mentioned in a will of the fifth century. Perpetua, Bishop of Tours, left the silver cross he used to wear and some other trinkets to a brother bishop, because he leaves the gold cross, etc., made by Maburnius to his church.

There were, and I hope still are, in the Cabinet of Antiquities in the Bibliothèque Nationale, Paris, the hilt of a sword in gold, gold bees and other objects, found in the tomb of King Childeric at Tournay, all of beaten gold.

One of the apprentices of Abbon, at Limoges, a youth named Eloi, was afterward one of the patron saints of French goldsmiths. St. Eloi, in his early days, was ordered to make a seat for the king—whether a saddle or a chair has never yet been quite decided—but he worked so diligently, so carefully and so honestly, that out of the gold intrusted to him he made two seats, without either being in any way defective, and he made the two in the time he was expected to make one; small wonder that he became minister to Dagobert the First, called "the great." Still, in the midst of all his grandeur and power, he worked as a goldsmith with his own hands, only assisted by his apprentice, Thillon, a Saxon.

In the time of St. Eloi there were three grades of goldsmiths—masters, companions and apprentices. St. Eloi founded a monastery at Solignac, where he taught the goldsmith's art to his monks. After the death of his master, Thillon became abbot, and continued the teaching of the craft. St. Eloi also founded a convent in Paris on a large piece of ground given him for the purpose, near where the Palais de Justice now stands. It was known as the Maison de Madame St. Aure (Aurata), from a virgin that came to Paris from Syria preaching the Gospel in Hebrew to convert the Jews. Perhaps she was chosen as first abbess on account of her name, for St. Eloi had his favorite art taught here also; and the convent became the center for gold embroidery for church work. The nuns were celebrated, not only for their exquisite work and the beauty of their designs, but also for the excellence of the gold thread they manufactured, which was purchased from them by all the world. The old accounts of this convent rather lead one to suppose that vessels and crosses for the service of the church were also made here; but I am not sufficiently sure that the nuns made them to cite those nuns as women goldsmiths.

In Paris, during the reign of St. Louis, strangers were allowed to work as goldsmiths, after they had lived for a year and a day in the quarter of the Pont au Change or Grand Pont. If they were approved as craftsmen and good fellows—for all this time they must have been under the observation of the masters of the craft, who certified them to be respectable men and good workmen—they had to pay a tax to the king, according to the value of the custom they had; there was one Richardin, the enameler from London, who paid an impost of 3 sous; Robert, the Englishman, who paid an impost of 12 sous; and many other names of foreigners are recorded as having practiced the craft at that period in Paris.

In the eleventh century the monk Theophilus, who wrote on many arts, wrote a treatise on gold work, which, when all the odd superstitions about the preparation of gold are eliminated, evinces a knowledge, and a practical knowledge, too, that would be hard to excel now.

Theophilus, whoever he was, and from whatever country he came (for these two details are not recorded, and the theory that he was of English birth never has been either proved or disproved), was a thorough master of all branches of the art; and a translation of his work will do more to help an amateur in his studies than any of the so-called technical hand books ever written.

The treatise commences by describing how the factory—*fabrica*—should be built. He recommends that it should be large and spacious, should have a wide window, with a good light; he directs that there should be planks put round the table where the workers sit, to catch the pieces of gold that may fall in working. To the left of the worker a furnace must be built, of well kneaded clay. He must have bellows, anvils, hammers, pincers, nippers, draw plates, screw plates, files, irons to scoop out the gold, to scrape it, to grave it, and to cut it. These "irons" are the great-grandfathers of our scrapers, split stickers (*speizsticker*), bull stickers, etc., used now. He does not mention "skins," always attached to the board nowadays, but probably the workers then wore leather aprons, which answers the same purpose.

This monk knew all the ordinary work. He tells how to begin and to finish cups for the altar, niello work, enameling, and almost all the details of every branch of the craft; and all that he describes he did with his own hands, even to the building of the furnace. How many craftsmen are there who could do this now? Many of them can only do one thing, and that indifferently well.

Theophilus taught that a lad must be apprenticed for not less than eight years; then that another term was desirable, and that if all that could be learnt was to be acquired, a further term of pupilage must be spent, to make a first rate master. Theophilus contended that it was necessary to be an apprentice for twenty-one years! In the Bibliothèque Nationale there is an engraving of Etienne Delaulne's workshop, done by himself. Etienne Delaulne was better known as "Stephanus." This engraving has been much copied, and the copies much used; it has even come down to be a frontispiece in a retail trade catalogue, but it is so very interesting that I asked my husband to prepare a slide for me from it, in order that I might point out to you the resemblance between a factory some five hundred years ago and one of the present day.

The Dictionarium of Magister Johannes de Garlandia gives some quaint accounts of customs in the trade, such as the rule that no master should be permitted to take a new apprentice before the one already bound was half out of his time, and that no master goldsmith should be permitted to take more than one outsider as an apprentice under any circumstances (by an "outsider" he means a lad, the son of a foreigner, or of a father who followed a calling other than that of a goldsmith).

The author of this dictionarium was of the noble family of Garlande; he followed William of Normandy into England. Both John Garlande and his Norman master were great patrons of the art; and I think Garlande could hardly have written as he did unless he could have worked himself, as well as describe the methods of work.

In all that concerns our subject the English were never far behind; there are Saxon jewels of great interest in the British Museum, and in the Ashmolean Museum there is King Alfred's jewel, a drawing of which will be shown presently; at any rate the commercial spirit of the English was always manifest. It is related how English treasure helped the Abbe Suger out of a great difficulty. I should remind you that the Abbe Suger was abbot of St. Denis, and minister to Louis VI. in the twelfth century. Suger had prepared a magnificent gold crucifix and other ornaments for his abbey church, but for a long time after they were ready he could not obtain the stones he required to finish them, until when he began to despair three monks from England came to him to sell the jewels removed from the table cups of our Henry I., jewels that the king's nephew, Thibaut, Count of Champagne, had given to various convents to procure indulgences and prayers. How the jewels came into the hands of these three monks I am unable to tell you, but history says that the Abbe Suger bought from these men, for a sum equal to £400 of our money, jewels that were at the time of priceless value. The crucifix was melted in 1590 by the leaguers.

In the eleventh and twelfth centuries much gold was used in the manufacture of cups and decorations for sacred purposes; probably that is why so few of them remain now.

The gold on the Paliotto executed for that very interesting church in Milan, St. Ambrogio, by the goldsmith Wolvinus, was valued at 280,000 gold crowns; it is a most beautiful piece of goldsmiths' work, enriched with cameii and intaglii, precious stones and enamel. Quintillian justly observes, "*Ars summa materia optima melior,*" and the value of the exquisite design and arrangement of this work is far above the value of the material employed, yet the value is, in this case, so far above price, that there is an additional reason for being glad it is still preserved to us. Count Blazini told me how nearly it was lost when Milan was entered by the famished soldiers of

Napoleon, and how it was saved by the adroitness of a priest, who knew that a small portion had either been stolen or lost, and that the vacant space had been supplied with a good imitation in copper gilt. This little accident was only known to a few of the priests, the outer world knew nothing of it When the soldiers entered the church, the priest advanced to them asking what they wanted. He was rudely answered, "The gold altar case and the gems set in it." "Alas!" he said, "would that we had a gold altar, its value would supply the wants of many; it is this gilt Paliotto," he continued, "that you must mean. Look! I will show you the gold." And he coolly broke away the restored copper gilt portion, saying, "Do you think, if the gems ever were real, those here now are better than the copper? No, poor fellows, it is not in this bare, half empty, poor old church that you will find treasure; go seek it elsewhere." And they went without touching the Paliotto.

There is much to be said about art of the kind in our own and other countries, but there are some illustrations to be thought of, and with your permission they shall now be shown and described.

The paper was illustrated by a series of lantern slides, taken from fine historical examples of jewelry in the Gold Ornament Room of the British Museum, and other great national collections.

Slide.

1. Assyrian gold cup of beaten work, very sharp and characteristic; one of the finest old pieces of work now extant.
2. Funeral wreaths (Etruscan).
3. Bracelet, with *repoussé* figures, fibulæ, etc.
4. Etruscan ear rings, ornaments to be sewn to garments, etc.
5. Etruscan necklace, heads of "IO," etc.
6. Etruscan necklaces, pins, etc.
7. Archaic Greek.
8. Archaic gold cup, etc.
9. Greek necklace, etc.
10. Greek necklace from island of Melos, etc.
11. Later Greek necklace, in form of stars, and Herculean knot in carbuncles.
12. Roman "marriage" brooch.
13. Early British torques.
14. Head ornaments, engraved; early British.
15. Byzantine cross, with Lord's prayer in the Cyrilic character.
16. Byzantine cross, with emblems of the "Passion."
17. Byzantine cross, and cross from Rheims Cathedral.
18. Anglo-Saxon ornaments.
19. King Alfred's jewel.
20. Reliquary from Royal and Imperial Treasury, Vienna.
21. Crown of Charlemagne, from Royal and Imperial Treasury.
22. Sword of Charlemagne, from Royal and Imperial Treasury, Vienna.
23. Arm bone reliquary, from collection Royal Irish Academy.
24. Cross of Corg, from collection Royal Irish Academy.
25. Fibulæ, from collection Royal Irish Academy.
26. Two views of a missal cover, from collection Royal Irish Academy.
27. One side of another missal cover, from collection Royal Irish Academy.
28. Shrine of St. Patrick's bell, from collection Royal Irish Academy.
29. Cross of Aberlemno.
30. Ornaments from Historical Museum, Munich.
31. Cellini pendant.
32. Gold and enameled mediæval cup.
33. Cover of above.
34. Dagger and sheath (Holbein).
35. Venetian cross, from house of Marco Polo.
36. Workshop of Etienne Delaulne (better known as Stephanus) from the engraving by himself in the Bibliothèque Nationale, Paris.

37 and 38. From the Worcester casket design by Mrs. P. H. Newman.

39. Mounting of opal cameo, designed by Mr. P. H. Newman.
40. Enameled brooches, designed by Mrs. P. H. Newman.
41. Gold brooch, designed by Mr. P. H. Newman.

THE SMALLEST BOOKS IN THE WORLD.

THE *Intermediaire des Chercheurs et des Curieux* asked, about two years ago, whether any volume was known of still smaller dimensions than a "Petit Paroissien de l'Enfance," printed without date by Firmin-Didot, and which is 1·12 inch in length by 1 inch in width. In answer to this question, we made known in *La Nature* a few volumes of smaller dimensions than the above named, and certain of which are in our possession. The smallest of the booklets mentioned by us, "Le Réveil-Matin," an almanac for 1871, measures but 0·75×0·5 inch. A bookseller of Paris having at that time assured us that he had seen a still smaller booklet, we in turn asked our readers, What is the smallest book in the world?

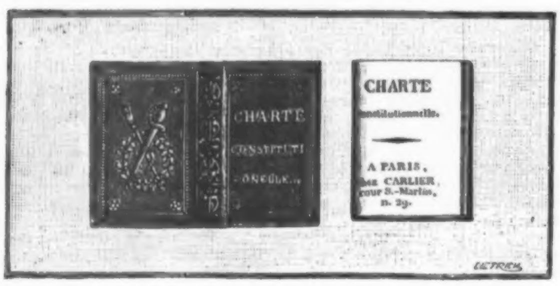


FIG. 1.—MINUTE FRENCH BOOK (Actual size).

FIG. 2.—OTHER MINUTE FRENCH BOOKS (Actual size).

FIG. 4.—MINUTE GERMAN BOOK (Actual size).

FIG. 3.—MINUTE ENGLISH BOOKS (Actual size).

FIG. 5.—MINUTE FRENCH BOOKS (Actual size).

At the time of writing our article, we were merely able to name the collection of a Parisian amateur, Mr. George Salomon. Since then, we have had the good fortune to visit this wonderful collection, and we really think that we found therein the smallest book or books that have ever been published—the microbes of the book! It comprises about seven hundred volumes published in France and other countries upon all subjects, from the most trivial to the most serious.

In order that a volume may be judged worthy of figuring in the collection, it must not exceed certain dimensions, a maximum size. Of course, concerning a minimum, there is no question. The maximum size (judge of the surprising effect of this liliputian library) is "La Fontaine," printed in microscopic characters by Laurent & Derby in 1850, the justification of which, that is to say, the length and width of the printed page, measures 2·16×1·32 inches. This is a type known to bibliophiles as 64mo, and classified in the National Library in the category of "dwarf books." As for this, we shall hereafter specify the dimensions of the book by its justification. Such determination appears to us more comprehensible than that of size for books so small, and it is more exact than the measurement of the page, which may have been cut more or less.

Around "La Fontaine," ranked as a giant, are found all the little works that may be considered as the classics of microscopic printing: "Les Œuvres d'Horace," 1828, from the press of Henri Didot (1·98×1·2 inch); "La Rochefoucauld, Maximes et Reflexions Morales," 1827, from the same press (1·68×0·84 inch); "De Imitatione Christi," Tross edition, 1858 (1·84×1·2 inch); the same from the press of Mame, 1862 (2×1·24 inches); "Le Rime di Petrarca," Venice, 1879, 2 vols. (1·56×0·96 inch); "La Divina Comedia di Dante," Milan, 1878, 1 vol. of 500 pp. (1·52×0·88 inch); etc., all bound with great perfection.

In the midst of numerous small books in Latin of the seventeenth and eighteenth centuries, we remark in a pretty cover of old morocco, a "De Oficiis" of Cicero published at Amsterdam in 1625; a small medical work, "Hippocratis Coi Aphorismi, ex Officina Plantiniana Raphelengi," 1617 (1·8×1·2); etc.

History and politics are likewise represented. Let us mention "La Constitution Francaise," etc., Paris, from the press of the Typographical Literary Society of l'Estrapade, No. 10, 1792 (1·6×1·56 inch); one of those small charters distributed in so great number and so difficult to find, "Etrennes Francaises ou la Charte Constitutionelle octroyée par le Roi au Peuple Francais," Paris, from the press of E. Jourdan, 1821, in its original paper cover (2·16×1·2 inch); and a constitution of Holland in Dutch, from the press of Joh. Enshedé en Zouen, Harlem, 1861 (1·56×1·2 inch), remarkable by the fineness and sharpness of the characters. We find further an epitome of the history of Holland, in Dutch, published at Amsterdam by Crajenschott, 1753, in 2 vols., bound in old calf and measuring 1·4×0·68 inch. They have respectively 146 and 266 pages and contain a large number of extremely fine figures of the principal persons and episodes of the history of Holland, some of which are displayed in plates nearly triple the width of the little volume. Of the same epoch and of the same size, but of less careful composition, there is an epitome of the history of the Church, in 2 vols., containing, together, 558 pp., published at Dordrecht.

Among the numerous religious works, there is a group of exquisite little primers and Bibles of the seventeenth and eighteenth centuries. Let us mention some of them: Two volumes bound in antique calf giving a series of 264 very small copper plate engravings on the Old and New Testament by two female artists, Christiana and Magdalena Kussler, who lived in Switzerland toward the end of the seventeenth century (1·68 × 1·36 inch); two smaller volumes (1·36 × 0·72 inch) of 84 and 83 very delicate engravings on the Old and New Testament, published at La Haye toward the middle of the seventeenth century; a catechism in German, of 1611, measuring 1·68 × 1 inch, in a binding of antique calf, with a small clasp of chased copper of the epoch. A curiosity among curiosities is the Siamese twins of books, one entitled "Catechismus Handlung" (187 pp.) and the other "Christlichen Haussard" (191 pp.) printed at Nuremberg in 1666 (1·24 × 1·24 inch). Bound in richly ornamented calf, they have one of the sides in common, and open in opposite directions.

Among the primers in French, let us mention "Heures Nouvelles dédiées à la Noblesse," Paris, Valleyre, Jr., 1781, 216 pp., with a calendar for 1783, bound in antique calf with stamped ornaments (2·08 × 1·2 inches); "Heures de Cour Contenant les Offices," etc., Paris, V. Cuissart, 1783, 252 pp., bound in antique calf (1·68 × 0·92 inch); "Heures de Cour Contenant les Sept Offices," published by S. Chardon in 1682, bound in calf with silver corners and clasps of the epoch (1·52 ×

0·88); "Heures à la Cavalière," Paris, T. de Hansy, 1751, 223 pp., old green morocco binding in a case of antique calf (1·32 × 0·8 inch); "La Sainte Bible mise en vers," by J. P. J. du Bois, at La Haye, P. Servas, 1754, 192 pp., several engravings (1·44 × 0·8 inch), old blue silk cover inclosed in an antique calf case entirely covered with stamped ornaments; "Le Reveil de l'Ame," Annecy, 1784, with 56 pp. (1·64 × 1·16 inch), in an old silk cover ornamented with golden threads and spangles.

Let us stop to admire, in their elegant covers of old morocco, several Bibles published at London during the first half of the eighteenth century and measuring 1 × 0·8 inch; and a German volume, "Begriff Christlicher Lehre," 1778, 64 pp., 0·88 × 0·44 inch, in bright green boards with silvered ornaments. In the board bindings of the epoch, often covered with figures, and as fresh as if they had just come from the hands of the stitcher, there is a full series of books designed for children or the gentler sex, and filled with pretty figures, charming as regards printing and subject, and almost all printed by the Didots during the first half of the present century.

Here we have a series of pocket song books elegantly bound in morocco, showing in a manner, by the difference between the printing and engraving at different epochs, the grandeur and the decadence of song in our country. The titles are suggestive: "Le Chansonnier joyeux de l'Amour et du Lit, à Cythère" (2 × 1·6 inches): "Chansons joyeuses et de Table," by Piron Colle and others, Paris, 1816 (2 × 1·7 inches).

The almanacs are of a more modest turn. There is here a series as rare as it is complete, extending almost uninterruptedly from 1790 to 1818. These books, published by Jubert, Janet, Le Fuel, Marcilly and others, measure, nearly all of them, 2 × 1·4 inches. With the calendar, they contain a selection of pretty songs and charming figures: those of the revolution are by Dorgez. Let us mention in particular a patriotic and gallant almanac of 1792: "La Civiologie portative ou le manuel des Citoyens." The frontispiece is a flory globe surmounted by a Phrygian cap and surrounded by tricolored flags. Viscount de Savigny of Moncorps, a learned bibliophile, and owner of one of the finest collections of old almanacs, has given some extracts from this in a recent study upon the most remarkable almanacs of the revolution. Mr. J. Grand-Carteret, a well-known art critic, has reproduced its frontispiece and its twelve engravings by Dorgez in the bibliography of French almanacs, which ought soon to appear.

All the almanacs just mentioned are bound in silk enriched with golden threads and spangles and colored embroideries usually representing the attributes of love, or in richly ornamented morocco, or sometimes in pretty boards of the epoch. The interior, lined with silk, with mirrors and a little pocket, is of the most elegant character. The silk cover of an almanac for 1774 bears a painting representing persons gazing at a boat flying with its pilot, a grand ancestor of the balloon. A few Dutch almanacs of the middle of the eighteenth century are got up in the style of our own. Their engravings and covers must have come from the hands of our artists. They measure for the most part 2·2 × 0·88 inches.

Certain English almanacs of the end of the eighteenth century and the beginning of the present are interesting by reason of the information and engravings that they contain, as well as by their stamped or mosaic morocco covers. Those of the London Almanac Series published for the Company of Stationers measure 2·2 × 1·12 inches.

We reach by degrees those tiny volumes that we formerly gave as the smallest books known, but which, as we shall see, have to compete with smaller ones still. There are here nearly two hundred of them, exhibiting their backs of gold, silver, morocco, silk or cardboard of the epoch.

In gold or gilded silver charms, they were formerly attached to chatelaines. This compartment of minuscules *par excellence* comprises a dozen prayer books, and a Constitutional Charter of 1814 measuring 0·88 × 0·5 inch, with an outer title of 68 pages. It is one of those rare dwarf volumes in which one does not sing of God, love, or gayety. In Fig. 1 we reproduce its title and its cover, which is of gilded and figured cardboard. Then comes a series of French song book almanacs published between the years 1769 and 1849 by Boulanger, Jubert, Janet, and others. But few years are wanting. The largest of the collection measures 0·95 × 0·55 inch, and the smallest from 0·7 to 0·75 × 0·45 inch.

In Fig. 2 are shown, among the booklets of this type, "Le Chansonnier Lilliputien," for 1820, entirely engraved, and in its boards of the epoch, and another song book in a morocco case in the form of a book.

The foreign minuscules are much superior to the French in the distinctness and fineness of the printing and engraving. At the beginning of the century, Austria published a wholly engraved oblong almanac without figures, "Mignon Almanach Wien," by Jos. Riedel, etc. The title occupies the first two pages, and the page measures 0·8 × 0·6 inch. These almanacs have pretty ornamented morocco covers, 0·84 × 0·68 inch, and are inclosed in cases of morocco or of gilded silver forming charms. The English almanacs published at London toward the middle of the present century under the title of "The English Bijou Almanac," measuring 0·55 × 0·4 inch, must be classed in the front rank of the series of booklets for the extreme fineness and beauty of the engraving of the text and figures.

It is impossible to reproduce here, in print, their text, or even their title, so microscopic are the characters. In Fig. 3 we show one of these pretty almanacs partly hidden in its cardboard case of the period, and lying in the casket in which it was sold along with a small magnifying glass mounted in tortoise shell. We show in the same figure, of actual size, the morocco cover of the almanac of 1842. In order to give an idea of these almanacs, let us notice some of them in detail:

"Schloss's English Bijou Almanac for 1843, poetically illustrated, by Miss Mitford (author of 'Our Village')," London, published by A. Schloss (fancy stationer to Her Royal Highness the Duchess of Kent), 12 Berners Street, Oxford Street. Before this title page come two pages of introduction in verse and an engraving representing the Prince of Wales. Within there are five other portraits, each accompanied with two pages of stanzas in honor of the person pictured. We see in succession Frederick William, King of Prussia, the Princess of Orleans, Samuel Rogers, Adelaide Kemble, and Ludwig Dobler. Then come the calendar and some information as to the royal house, the ministers, etc., in all forty-seven pages. The almanac of 1837 contains a dedication to the Queen, and seems to be the first of the series. Among its figures there is a charming portrait of Malibran, accompanied with stanzas and four pages of a rondo in microscopic music with words. In Fig. 3 we reproduce, of actual size, two of the engravings of the almanac of 1842, representing the princess royal and Rachel, the tragedienne.

There are some almanacs smaller still, published between the years 1817 and 1840 by the Lithographic Institute of C. F. Muller, at Carlsruhe, and that measure but 0·55 × 0·35 inch. As in the preceding, the characters are so fine that we can reproduce here neither their text nor title. They contain from 26 to 28 pages and from 6 to 12 engravings. Fig. 4 shows, of actual size, the cardboard cover, one of the engravings and a page, with slightly enlarged characters, of the almanac for 1819. The almanac for 1831 bears upon one of the sides of the cover a portrait of an Algerian man and on the other an Algerian woman. Algeria was then all the rage. Within, there are charming portraits of Sontag, Paganini, Franz, Napoleon and of Hussein Pacha, the last Dey of Algiers, etc. On the sides of the cover of the almanac for 1832 there is a portrait of Mohammed II. and his favorite, and, within a series of Turkish personages. The almanac for 1834 contains the portraits of Gen. Jackson, Frederick William, Prince Royal of Prussia, and Otto, King of Greece. Then comes a series of tales, with an outside title occupying one page: "Blumen, Deutung Componirt und auf Stein ausgefuhrt von G. Nehrtich." Through the microscopic text are found scattered numerous vignettes of rare fineness. The other volumes of this series are of a piece with those that we have just sketched in a general way.

As small as these Carlsruhe almanacs are, they are still not the smallest of this unique collection. The minimum size of the library is furnished by a Chemin de la Croix and a Paroissien (prayer book) that measure but 0·55 × 0·24 inch!

Fig. 5 shows, of actual size, the gilded silver, delicately chased charms into which they are set, and the title and one of the engravings of the "Chemin de la Croix," which contains 119 pages and numerous vignettes. After such infinitely small products of the press, let us draw the curtain. Have we not shown the smallest books in the world?—*G. Tissandier, in La Nature.*

STEREOCHEMISTRY, OR CHEMISTRY IN SPACE.

THEORIES become modified and improved in measure as the needs of science increase and its exigencies become more imperious.

At the origin of organic chemistry, which is nothing but the chemistry of carbon, and which now, let us say by the way, comprises the study of nearly a hundred thousand bodies, one was content to represent compounds by crude formulas in which letters affected by exponents indicated the relative proportions of the atoms constituting the molecules. Methane, for example, was written CH_4, the letter C representing the atom of carbon, and the letter H the atom of hydrogen.

But it was very quickly seen that such formulas could not account for the differences existing between certain properties of bodies that had, nevertheless, the same centesimal composition, or, that, in other words, were isomeric.

Thus, acetate of amyle has for rough formula $C_7H_{14}O_2$. It is produced by the action of acetic acid ($C_2H_4O_2$) upon amylic alcohol ($C_5H_{12}O$).

Propionate of butyle, likewise, has the formula $C_7H_{14}O_2$. It is a product of propionic acid ($C_3H_6O_2$) and butylic alcohol ($C_4H_{10}O$). In both cases one molecule of water is eliminated.

Upon analysis, acetate of amyle and propionate of butyle will furnish the same figures. Yet their boiling point and their density do not agree. These two bodies are, therefore, not identical. In the internal arrangement of their molecules there is something that we cannot determine with certainty in the present state of science, but which causes them to behave differently, not only from a physical, but also from a chemical point of view.

In fact, the acetate of amyle is capable of regenerating acetic acid and amylic alcohol; and so, too, the propionate of butyle is capable of splitting up into its constituent elements. It is, therefore, natural to think that in these two bodies the radicals of amylic alcohol and of acetic acid, on the one hand, and of propionic acid and butylic alcohol on the other, unite in preserving respectively their primitive molecular grouping. Hence their formulas will be able to be written: $C_2H_3O_2$, C_5H_{11} for acetate of amyle, and $C_3H_5O_2$, C_4H_9 for propionate of butyle.

This first step taken, it was desired to go further.

Gerhardt devised typical formulas that rendered evident, in the molecule, the groupings of atoms that preserved themselves intact in reactions. The impossibility of explaining with such formulas the reactions of the polybasic acids studied by Graham, Wurtz and Liebig, and of the polyatomic acids by Wurtz and Berthelot, made one think of doing better.

It certainly took a long time to discover the truth. It required the splendid work and persevering sagacity of Cahours, Kolbe, Frankland, Wurtz, Kekule, and Couper to reach the suspicion in the first place and then to render evident those mysterious attractive forces that manifest themselves in the atoms, and that are called valences.

It is to Kekule and the unfortunate Couper that is due the honor of having clearly established the quadrivalence of carbon, that is to say, the presence of four centers of attraction invariably existing around each atom of it. Wishing in nowise to prejudge as to the form of the atom or as to the nature of the forces acting and as to their orientation, Kekule contented himself with representing the atom by a letter and the valences by lines arranged regularly around such letter.

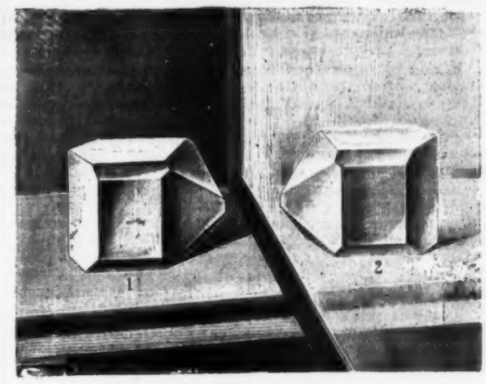


FIG. 1.—CRYSTALS OF DEXTRO AND LEVO TARTARIC ACID.

At the extremity of each of the lines another letter figured the atom that saturated a valence.

The atom of carbon became then:

$$\begin{array}{c} | \\ -\mathrm{C}- \\ | \end{array}$$

and methane was written:

$$\begin{array}{ccccc} & & \mathrm{H} & & \\ & & | & & \\ \mathrm{H} & - & \mathrm{C} & - & \mathrm{H} \\ & & | & & \\ & & \mathrm{H} & & \end{array}$$

Kekule's plane formulas served well to explain some isomeric bodies that were, until then, incomprehensible, and to cause to be foreseen the existence of numerous bodies that chemists succeeded in preparing.

What more brilliant confirmation could the hypothesis of the quadrivalence of carbon have received?

Meanwhile, chemistry was progressing, and a day came in which, before certain facts, plane formulas had to remain mute. It was evident that they were only a makeshift. It would be impossible to represent upon a plane, except in projection, what takes place in space.

Imbued with this idea, and already enlightened by the labors of Mr. Pasteur on the tartaric acids, Messrs. Le Bel and Van't Hoff created stereochemistry, erecting in space molecular edifices which, although hypothetical, threw, nevertheless, an entirely new light upon chemistry.

Tartaric acid,

$$\begin{array}{c} \mathrm{CO_2H} \\ | \\ \mathrm{CH.OH} \\ | \\ \mathrm{CH\ OH} \\ | \\ \mathrm{CO_2H,} \end{array}$$

is capable of exhibiting itself under four different isomeric states. What especially characterizes these isomeric bodies is their action upon polarized light. One turns the plane of polarization to the right, and is called *dextrotartaric acid*. Another turns it to the left to the same degree, and is known as *levotartaric acid*. The third, which is optically inactive, is a combination of equal parts of the dextrotartaric and levotartaric acids, and is called *paratartaric* or *racemic acid*. It is capable of being reduced into its constituent elements. Finally, the fourth is not reducible, and is called *inactive tartaric acid*.

Mr. Pasteur had the honor of discovering the cause of the singular phenomenon exhibited by the dextro-

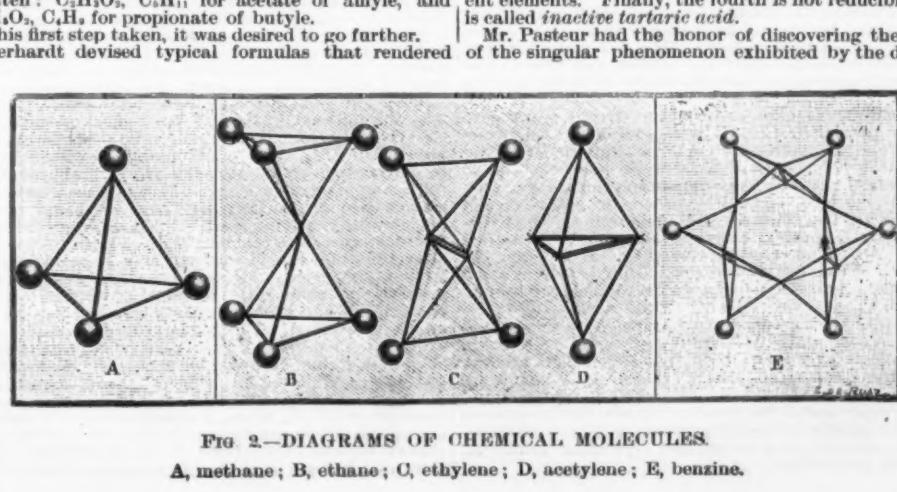


FIG 2.—DIAGRAMS OF CHEMICAL MOLECULES.

A, methane; B, ethane; C, ethylene; D, acetylene; E, benzine.

tartaric and levotartaric acids. He considered it probably due to the asymmetry of the molecule that manifests itself on the crystals by the existence of hemihedral faces. The crystals of the first acid are hemihedral to the right, while those of the second are hemihedral to the left; in other words, the first are, in a mirror, the images of the second.

This is clearly seen in Fig. 1. The rotary power is, therefore, intimately connected with the asymmetry of the crystalline form.

Mr. Sarran has, in addition, shown by calculation that it suffices, in order that there may be an action upon polarized light, that the latter shall traverse an asymmetrical medium. The molecular asymmetry suspected by Mr. Pasteur has been rendered evident by the researches of Messrs. Le Bel and Van't Hoff. It is shown by the influence exerted upon polarized light by bodies having asymmetrical molecules.

Messrs. Le Bel and Van't Hoff represent the atom of carbon by a tetrahedron. The valences are directed from the center to the four summits. In order to render this hypothesis, which serves as a basis to stereochemistry, wholly tangible, there are ordinarily employed small metallic tetrahedrons, to the summits of which may be fixed balls of different colors representing the atoms of the bodies capable of uniting with carbon.

Fig. A of our second engraving represents methane (CH_4). To each of the four summits of the tetrahedron is fixed a small ball, representing the atom of hydrogen.

The simple junction of two atoms of carbon is represented by the contact of two summits. Ethane (Fig. 2, B) offers us an example of it:

$$\begin{array}{ccccc} & H & & H & \\ & | & & | & \\ H- & C & - & C & -H \\ & | & & | & \\ & H & & H & \end{array}$$

The coincidence of two tetrahedric edges figures the double junction. Ethylene (Fig. 2, C) contains one of them.

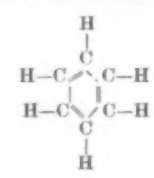
$$\begin{array}{ccc} H & & H \\ | & & | \\ C & = & C \\ | & & | \\ H & & H \end{array}$$

Triple junction, such as it exists in acetylene,

$$H-C\equiv C-H,$$

is represented (Fig. 2, D) by the union of two tetrahedrons having one base in common.

For benzine, the hexagonal formula of Kekule,



is represented by a grouping of six tetrahedrons (Fig. 2, E) offering alternately simple and double junctions.

Messrs. Le Bel and Van't Hoff have found that in order that there may be asymmetry, it is necessary that the four valences shall be saturated by four different atomic groups. All the known compounds possessing a rotary power contain at least one of these atoms of carbon, which they have called asymmetrical.

The bodies that have furnished the most striking proofs of this law are very numerous. To make a list of them would be tiresome. We shall be content to take tartaric acid:

$$\begin{array}{ccc} & OH & \\ & | & \\ CO_2H- & C & -CH.OH-CO_2H \\ & | & \\ & H & \end{array}$$

and the glucoses:

$$\begin{array}{ccc} & OH & \\ & | & \\ CH_2OH- & C & -(CH.OH)_2-COH, \end{array}$$

in which we make evident one of the atoms of asymmetrical carbon.

Some compounds seemed, for a certain length of time, to form an exception to the common law. Thus, propylenic glycol and normal secondary amylic alcohol, which possess, however, one atom of asymmetrical carbon, are inactive upon polarized light. This is due to the fact that they consist, like racemic tartaric acid, of equal parts of dextro and levo bodies. If, as has been done by Mr. Le Bel, one of the two modifications be attacked with micro-organisms, the rotary power immediately appears.

Mr. P. Guye has desired to penetrate the molecular structure of bodies still more deeply than the two bold creators of stereochemistry. He has endeavored to ascertain mathematically the extent and direction of the rotary power, and has succeeded in doing so in a certain number of cases.

The new theory has already borne fruit. It is due to it in particular that it has been possible to explain the long obscure isomerism of malic and fumaric acids, and it is due to it, also, that Mr. Fischer has been able to make his remarkable researches upon the sugars.

As Mr. Friedel has well said, stereochemists do not conceal the fact that there is something of the hypothetical and, perhaps, a little crudeness in the method of representation that they employ. It is none the less true that it constitutes a step in advance of great importance, since it now accounts for delicate isomerisms of various orders, and, while permitting of coordinating all those that are known up to the present day, gives us only the number of them desired, and verified by experiment, in all cases in which verification has been made. It is, therefore, a wonderful working tool that has been furnished to chemists and at the same time a first conducting wire for the solution of the long since proposed problem of the relation between chemical composition and crystalline form.—*M. Otto, in La Nature.*

NEW FORMS OF APPARATUS FOR ORGANIC ANALYSIS.

By Dr. JAMES LEICESTER, F.C.S., Lecturer on Chemistry and Metallurgy, Merchant Venturers' Technical School, Bristol.

I BEG to draw the attention of chemists to the following forms of apparatus which were made for me by Herr Hildebrand, of Erlangen, when working in the research laboratory of Professor Otto Fischer in 1888. I have used them in my research work during the past six years, and have found them a help in many ways.

The first of the small bottles, Fig. 1, is filled with

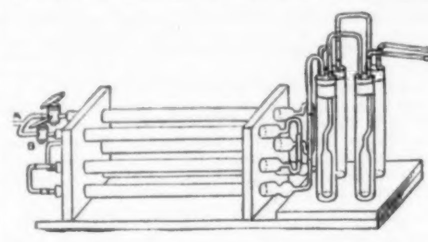


FIG. 1.—APPARATUS FOR DRYING GASES.

KHO solution; the second, with H_2SO_4 (conc.) The gas then circulates along the tubes and out at the end marked A. The tubes are filled in the usual way with KHO and $CaCl_2$, glass wool being placed near to the corks.

One side of the apparatus is connected to an air cylinder and the other to a cylinder of oxygen, the taps at B regulating which gas is passed through. The whole apparatus is fitted into a wooden stand.

The tube is filled in the usual way with a little glass wool at the top and has the form as shown in B, Fig. 2.

The long limbs are then sealed in the blowpipe, as shown in the lower figure.

A little piece of tubing passes into the bulb, as shown at A, and prevents most of the water from coming into contact with the calcium chloride. The whole apparatus is obviously air tight.

The form of glass wash bottle, as shown in Fig. 3, is useful in the case of substances that would act upon cork or India rubber. It is perfectly air tight, the gas bubbles through the circle of small holes at the base of A, and the bulb, A, prevents the liquid being drawn back.

The preparation of ethylene dibromide is conveniently performed in such a way, the bottle being filled with bromine.

Flasks of the form shown in Fig. 4 are very useful

FIG. 4.

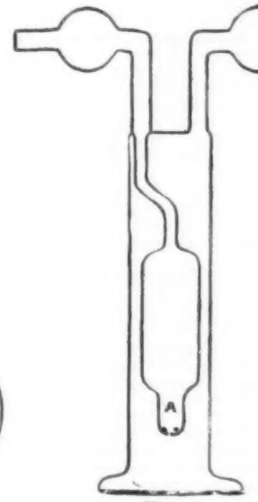


FIG. 3.

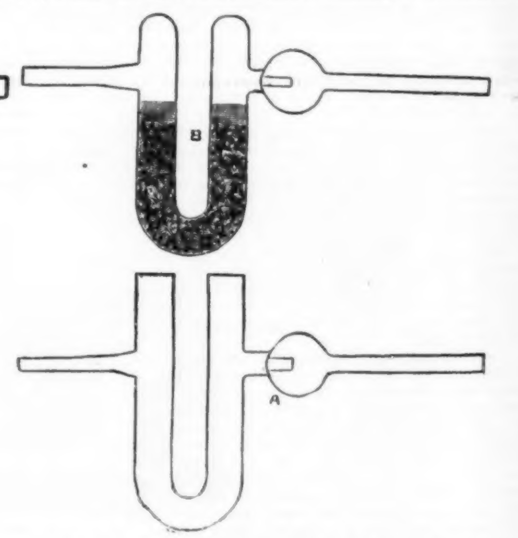


FIG. 2.—NEW CALCIUM CHLORIDE TUBE.

to keep the powdered and lump oxide of copper in for analysis. The flasks are strongly heated, and then the ignited oxide of copper poured into them, a copper funnel being used.—*Chem. News.*

CHLORINE.

AT a recent meeting of the London section of the Society of Chemical Industry, Mr. F. Bale read a paper on the "Commercial Production of Chlorine by the Ammonia-Soda Process." The outline of the process is given in the following abstracted description of the various stages of the preparation. At the outset, ammonium chloride in powder is mixed with magnesia in powder, and heated in a series of retorts one above the other. The ammonia is evolved in a downward direction through exits at the bottom sides of the retort; the volatilization of ammonium chloride being thus prevented. The ammonium chloride powder is mixed by stirrers, revolving through the cylinders. When the ammonia has been evolved, superheated steam is passed through the mixture; passages being opened for it by the revolving stirrers; and a strong current of hydrochloric acid is evolved. The mixture above stated, after the ammonia is evolved, may be agglomerated by spraying with a solution of ammonium chloride, and stirring sufficiently to allow of the subsequent passage through it of superheated steam after the ammonia is evolved. The pure hydrochloric acid thus evolved is then dried by a current of strong sulphuric acid, descending a Glover tower, heated up in a Cowper stove, and passed into a Deacon furnace containing peroxides, made into marbles, and heated up to a temperature of 550° C., when a strong current of chlorine is evolved, which can be used at once for the manufacture of bleach. Two-thirds of the hydrochloric acid thus used become fixed as chloride, from which it may be removed as dilute chlorine by heated air, or as hydrochloric acid by steam. The hydrochloric acid so obtained is passed into another series of cylinders containing peroxides, and strong chlorine may be obtained as before. As a continuous process for the production of chlorine, the author proposed to mix the hydrochloric acid gas evolved, as above described, in proper proportions with air; both having been previously dried, and heated to the required temperature, when a continuous current of dilute chlorine is obtained of 40 per cent. or more, from the bottoms of the cylinders, and which is practically free from hydrochloric acid if the drying has been carefully done, and so may be used at once for the production of bleaching powder. Mixtures of hydrochloric acid gas, air and steam may also be used with more or less advantage, the gases evolved being afterward treated in separate cylinders, which for this purpose may be connected on the principle of the Hargreaves cylinders.

QUANTITATIVE WORK FOR BEGINNERS IN CHEMISTRY.

By W. A. NOYES.

IN most chemical laboratories the work which is given to beginners is chiefly or altogether of a qualitative nature. In many schools and colleges the work begins with a study of the qualitative properties of a series of chemical elements and their compounds, chiefly of gases and metalloids. In other schools the students begin at once with the study of qualitative analysis. A large majority of students never get beyond this first stage, and it is safe to say that they acquire but a very slight knowledge of real chemical work. The work which is done in scientific and technical laboratories and in chemical factories consists almost entirely of quantitative analyses or of the preparation of chemical substances carried out in an accurate quantitative manner. Indeed, we are accustomed to say that the science of chemistry began with the use of the balance, and we all recognize the extreme importance of quantitative relations in most of our chemical work.

We must keep in view several objects in selecting the laboratory work for beginners. First, they should become personally acquainted with the appearance and properties of a number of the chemical elements and their compounds. The acquisition of a large amount of knowledge of this kind is desirable, but we may easily make the mistake of endeavoring to impart too much. A few topics exhaustively studied will prove of greater value than a superficial study of a great many. This is especially true of qualitative tests with solutions. A beginner can apply a great many such tests in a comparatively short time, but unless his powers of discrimination and of memory are very unusual, he will retain only a confused recollection of his work. A second object is to secure a training in delicate and accurate manipulation and in the use of different forms of apparatus. A third object is to fix in the mind of the student knowledge which may have been imperfectly acquired by watching the demonstrations of a lecturer or by the study of a text book. Some teachers carry this thought so far that they seem to imply that no knowledge of a topic can be really acquired by the student until he has demonstrated it by personal experiment. Indeed, I have heard some teachers contend that they would not allow a text book in the laboratory, but would have their students acquire all of their knowledge at first hand by their own experiments. Such a principle, if logically carried out, could never take the student beyond the stage of alchemy, for the student of to-day is no better able to develop a science of chemistry for himself than was the old alchemist. And if you direct his experiments in such a way as to develop and elucidate the science as it is now known, you have forsaken the principle just as much as though a text book were used.

It seem to me that such views arise from a mistaken conception of the real nature and purpose of laboratory instruction. After all the method of personal experiment is a very slow and laborious method of acquiring knowledge. Only a very small fraction of our knowledge of a science, if that knowledge is by any means adequate, has been acquired in that way. It is true that the method is absolutely essential for beginners, and I do not think that any of us get beyond the need of it. The man who never uses a balance or handles a test tube will not for very long be a strong factor in the advancement of chemical science. But the method of laboratory instruction is essential, not because knowledge cannot be acquired in other ways, but because at the start the imagination of the student is deficient, and it is only by means of personal experiments of his own that he can acquire the ability to un-

derstand and appreciate the experimental work of others. The memory is also deficient, and the personal work on a subject may be of great value for that reason as well. But the things which we should endeavor to secure in laboratory instruction are, first, such an acquaintance with experimental methods as shall enable the student to thoroughly grasp the solid experimental basis of the science and give him the mental habit of referring everything back to the rigid experimental test; and second, the ability to do accurate and independent experimental work himself. No student can demonstrate for himself more than an infinitesimal number of experimental facts in comparison with the vast array of such material which has been accumulated.

If the principles which I have suggested are correct, we should endeavor to secure as thorough a knowledge as possible of experimental methods, and neatness and accuracy in laboratory technique rather than the illustration of as large a number of details as possible. These results can be secured more fully by a series of quantitative problems than by a large amount of merely qualitative work. I do not mean by this that qualitative work is not necessary and desirable as well, but for the beginners, especially, quantitative work is of more value. In order to make my meaning more clear I will give a few illustrations. One of the earliest problems that I give is the determination of the weight of a liter of hydrogen essentially by Regnault's method. A bulb containing about one half a liter and bearing a three-way cock is exhausted with a Bunsen pump and the residual pressure determined with a manometer. The bulb is then weighed, using a sealed counterpoise of nearly the same volume, then filled with hydrogen, temperature and pressure noted, and weighed again. The results obtained by careful work are usually one or two per cent. too high. A similar determination of the weight of oxygen gives results with a far smaller percentage error. The determination of the amount of oxygen in potassium chlorate by heating about a gramme of the salt in a small porcelain crucible placed within a second gives a good illustration of the law of constant proportion. The preparation of potassium perchlorate can be made to furnish a considerable amount of valuable instruction. The capacity of a bottle holding about two liters is determined, a calculation of the amount of potassium chlorate required to give oxygen enough to fill it when only the first stage of the reaction is used is made, and the experiment performed. Then the potassium chlorate and potassium perchlorate are separated and the latter is purified by crystallization. A study of the qualitative reactions which distinguish potassium chloride, potassium chlorate and potassium perchlorate is made and the tests to establish the purity of the last are applied. Finally a determination of the amount of oxygen in potassium perchlorate gives, in connection with the last problem, an illustration of the law of multiple proportion. I will give but one further illustration—the determination of the relative atomic weights of hydrogen, chlorine, and silver. A known weight of pure silver is dissolved in nitric acid, precipitated with hydrochloric acid and the silver chloride weighed on a Gooch crucible. In a dilute hydrochloric acid the amount of hydrogen is determined by allowing 10 c. c. of it to act on an excess of zinc in an appropriate apparatus, the hydrogen being measured in a gas burette, accurate corrections being made for temperature, pressure, and aqueous pressure. In another known volume of the same acid the chlorine is determined by precipitation with silver nitrate.

By a careful selection of problems it is possible to give the student, within a reasonable time, practice in the careful use of the more common forms of chemical apparatus. In other words, the student can make a beginning at working as a chemist works instead of doing scarcely more than play with bottles and test tubes. Among other advantages of this method of instruction is the fact that the results which are obtained are usually a fairly good criterion by which to judge of the care with which the student has worked, and the student soon finds that careless work will not give good quantitative results. Also the student dwells long enough on a problem so that many details become thoroughly fixed—a result that is rarely obtained in qualitative work, except by means of many repetitions. I am aware that there are some practical difficulties in the way of carrying out the methods which I propose, especially in the matter of apparatus, but these difficulties are not nearly so great as they appear at first sight, and I am sure that they are not greater than those which have been overcome in many of our physical laboratories.—*Jour. Am. Chem. Soc.*

THE SYNTHETIC POWERS OF MICRO-ORGANISMS.

By O. LOEW, University of Tokio, Japan.

AMONG all living organisms the micro-organisms, micrococci as well as bacteria, bacilli, and spirilli, are especially remarkable for their intensity of chemical activity. Oxidations and decompositions, reductions, and synthetical processes are effected on an extensive scale.

If we consider the destructive and the synthetical operations, we must arrive at the conclusion that the former are necessary for carrying on the latter. The former yield not only the forces necessary for the synthetical work, but also the suitable atomic groups. It is certainly a highly interesting question of physiological chemistry to study the relations of the two different directions and to elucidate which are the groups that serve for the synthetic work. We must first consider the chemical structure of the compounds that can serve as nutrients, we must investigate the causes that bring about the transformation of potential into actual energy, and we must recognize above all that the proteids of the living protoplasm are chemically distinct from those of the dead. We must acknowledge that when the labile character of the former changes by atomic migration into a stable one, the death of the cells has come.

Nutritive and poisonous qualities are relative conceptions. Poisons may become nutrients for bacteria when highly diluted, as phenol or acetic ether, and nutrients may become unfit for nutrition if the concentration reaches certain limits. Small chemical changes may convert a nutrient substance into a poison and again the poison into an indifferent substance.

As albuminous matter contains carbon, hydrogen, nitrogen, sulphur, and oxygen, we have to consider principally the question, which substances are suitable sources for the carbon, which for the nitrogen, which for the sulphur. Our experiments lead to the following conclusions:

1. As sources of carbon can be used in neutral or feebly alkaline solutions, alcohols, phenols, organic acids, ketones, aldehyds, carbohydrates, ethers and esters, many alkaloids.

2. As sources of nitrogen can serve: ammonium salts, nitriles, amido-acids, amines, ureas, guanidines, alkaloids, nitrates, and nitrites.

3. As sources of sulphur may serve: sulphates, sulphites, hyposulphites, sulpho-acids, mercaptans, sulphones.

It is remarked in a note that the nucleins, which contain phosphoric acid in their molecule, are here left out of consideration.

The following conclusions are drawn for most of the non-pathogenic microbia:

1. Hydroxylated acids are better than the corresponding non-hydroxylated ones, *e. g.*, lactic acid is better than propionic acid.

2. Polyvalent alcohols are more favorable for the development than the corresponding monovalent alcohols, *e. g.*, glycerin is better than propylic alcohol.

3. The nutritive quality of the fatty acids and monovalent alcohols decreases with the increase of the number of carbon atoms in their molecules. Thus acetic acid is better than butyric acid.

4. The entrance of aldehyd or keton groups increases the nutritive properties; glucose is better than mannite.

5 I have observed neither nutritious nor poisonous properties in picro-nitric acid, chloral hydrate, pinakon, ethylendiamine, glyoxal, amido-acetal. Acetoxime, diacetonamin, and maleinic acid are very poor nutrients. According to B. Meyer, mesaconic, citraconic, para methyl-succinic, dimethyl-succinic, and benzoyl-succinic acids are not capable of serving as food.

6. The poisonous properties are determined by the energy with which the unstable atoms of the living protoplasm are attacked.—*Central-Blatt f. Bacteriologie; Chemical News.*

INCOMPATIBILITY.*

JAMES KENNEDY, Ph.G., M.D., Professor of Pharmacy, University of Texas.

BY the term incompatibility we mean that property possessed by certain bodies which renders them uncongenial to certain other bodies, and occasions a change in either one or both substances affecting either their physical or chemical constitution when brought into contact with each other. This definition applies to chemical and physical incompatibility.

We may study our subject under four different heads, as follows: 1, chemical; 2, physical; 3, pharmaceutical; 4, physiological.

Chemical Incompatibility.—Substances are said to be chemically incompatible when they react upon each other in such a way as to produce a new compound occasioning changes in the atomic structure of both. Acids and alkalies are incompatible, for the reason that there exists an affinity between them sufficiently strong to cause them to unite chemically. Their atoms enter into a close chemical union, and produce a new substance which possesses properties differing widely from either of its constituents.

If common bread soda (soda bicarbonate) is added to muriatic acid, we will find that the mixture will effervesce, owing to the escape of carbonic acid gas (CO_2). The resulting solution no longer possesses the characteristics of either the acid or the soda, and by evaporation of the solution we obtain the product of their union, which is common salt. The muriatic (hydrochloric) acid being composed of hydrogen and chlorine (HC_1), the soda of sodium, and carbonic acid (CO_2) (having the composition of Na_2CO_3), double decomposition ensues, the sodium (Na) uniting with the chlorine (Cl) to form sodium chloride (NaCl), the hydrogen with a part of the oxygen to form water (H_2O), and the carbonic acid gas escapes (CO_2).

Another instance of chemical incompatibility, and one which will serve to illustrate the importance of a knowledge of the subject to both pharmacist and physician, is the changes occurring on the admixture of calomel (mercurous chloride) (HgCl) with muriatic acid. The acid nearly always containing free chlorine, the mercurous chloride takes up another atom of chlorine from the acid, and is converted into mercuric chloride, or corrosive sublimate, a compound differing greatly from calomel, both in its chemical constitution and physiological effect, the former being a relatively harmless cholagogue, while the latter is a powerful alterative in small doses, and a violent corrosive poison when taken in large amounts. . . .

Among the common errors that physicians make as pertains to compatibility in prescriptions are the following: Ammonium carbonate with sirup of squill in cough mixtures. These two substances are incompatible, for the reason that the sirup contains an acid (acetic) which acts chemically upon the ammonium salt, decomposing it, with the formation of ammonia acetate. Tannic acid is sometimes prescribed in combination with tincture chloride of iron, with the view of increasing the astringency of the mixture. The result is that an inky mixture is formed by the union of the tannic acid with the iron, which, in addition to producing an unsightly preparation, possesses less astringent power than was formerly possessed by either one of the constituents of the prescription. The same result will obtain if we combine preparations of iron with fluid extracts or tinctures containing tannin. Most vegetable substances contain tannin in greater or lesser amounts; therefore, if it is desired that iron should be combined with the active principle of the plant, the vegetable preparation should first be detannated; that is, have its tannin removed by the process of precipitation with the white of an egg. The tannin combines with this form of albumen and produces an insoluble compound which may be separated by filtration, leaving the liquid entirely free from its presence. The iron may then be added without producing any discoloration. There are a few drugs, such as gentian, calumba and capsicum, which do not contain any tannin, and may be combined with the salts or iron without producing any discoloration.

Iodide of potassium is frequently prescribed in solutions containing spirit of nitrous ether, and in the majority of instances a discoloration of the mixture results in a short time. This discoloration will not occur if the nitrous ether is perfectly fresh and pure. If, however, a slight decomposition has resulted, and owing to the facility with which decomposition occurs in this compound when exposed to light and air the preparation is seldom found pure on the apothecary's shelf, and may be safely set down as not being a good thing to prescribe in this form of combination. The discoloration which is produced is due to free iodine, resulting from the decomposition of the potassium iodide by acetic acid contained in the nitrous ether as a product of its decomposition under the influence of light and air.

Nitrous ether is often prescribed in combination with antipyrine, but these substances are incompatible in a high degree. The speaker was the first to call attention to the incompatibility of these substances, and in a paper which appeared in the *Pharmaceutical Record*, of New York, he published his researches on this subject. In a later and more exhaustive research conducted by him on antipyrine, the resulting compound was studied both chemically and physiologically (see proceedings of Texas State Pharmaceutical Association, 1889), and the influence of the changes in the substances due to the chemical decomposition, as affecting their medicinal value, was determined. The conclusions were to the effect that the new compound formed is not poisonous, and practically inert; that both the spirits of niter and antipyrine have their medicinal value lessened in proportion to the amount of each suffering decomposition. A mixture of antipyrine and nitrous ether will deposit green crystals if allowed to stand, provided there is not sufficient water present to keep the new substance in solution.

Acetate of lead and sulphate of zinc are frequently ordered in combination for use in the treatment of inflammatory affections of the genital mucous membranes, under the impression that the constringing power of these drugs is enhanced by so doing. This is a mistake. Double decomposition occurs when these two salts are dissolved together; sulphate of lead is precipitated as an inert substance, while the acetic acid is transferred to the zinc to form zinc acetate.

Strychnine is sometimes prescribed in combination with the bromides or iodides. This is a dangerous practice, for the reason that if the mixture has been allowed to stand for some time the bromide or iodide of strychnine will crystallize and be deposited in the bottom of the vial, and as the last dose of the medicine is taken the greater portion of this powerful drug contained may be swallowed, and perhaps with fatal results.

Illustrations of chemical incompatibility might be multiplied *ad infinitum*.

The following rules should be borne in mind:

Acids should never be prescribed with alkalies or their carbonates.

Alkaloids should never be prescribed in combination with alkaline carbonates.

Salts of the alkaline earths, *i. e.*, magnesium, calcium, barium and strontium, should not be prescribed with soluble carbonates, tartrates or oxalates, and in the case of the three latter elements they should never be combined with soluble sulphates, phosphates, arsenates, phosphoric or sulphuric acids.

The heavy metals, such as iron, manganese, lead, mercury, silver and zinc, should never be prescribed in conjunction with the alkalies, their carbonates or oxalates.

Silver should never be prescribed in combination with chlorides, bromides, iodides or hydrochloric acid or organic matter (substances of vegetable or animal origin).

The soluble salts of lead should never be combined with chlorides, hydrochloric, hydrobromic, hydriodic or sulphuric acid.

It is impossible to tabulate in a lecture of this kind the various incompatible combinations and mixtures, nor would such a tabulation be of any considerable use to either physician or pharmacist. An intimate knowledge of the chemical nature of the substances dealt with is the only infallible guide, the only beacon that can be relied upon to guide us safely past the treacherous shoals of this formidable gulf.

Physical Incompatibility.—By physical incompatibility we mean that property possessed by certain substances which causes them to change their physical properties when brought in contact with each other without affecting their chemical composition, a quality that in many instances may be overcome by the exercise of pharmaceutical skill. For instance, oils are physically incompatible with water (because of a lack of adhesion) and aqueous mixtures, but by the intervention of some viscid substance, *i. e.*, gum acacia, they may be rendered miscible in all proportions. Solutions of resinous drugs are physically incompatible with aqueous solutions, but by the intervention of some saccharine or mucilaginous material many resins may be rendered quite homogeneous.

Pharmaceutical Incompatibility is represented by that class of substance which, by virtue of possessing some property or properties that occasion an undesirable change when brought in contact with each other, and which cannot be overcome or prevented by the exercise of pharmaceutical skill. Of course, in this class of incompatibles we may have the occurrence of either physical or chemical change; for instance, when two or more salts are ordered in powders, and the water of crystallization of one is absorbed by the other, with the effect of liquefying the powder. Strongly alcoholic solutions are incompatible with sirups, for the reason that the sugar is very much less soluble in such media, and in the course of several hours a considerable proportion will be found deposited in the bottom of the bottle, making a very unsightly mixture.

A prescription may be said to be pharmaceutically incompatible when an amount of a given salt which is in excess of its solubility is ordered dissolved in the liquid.

Physiological incompatibility is the property pos-

* Lecture delivered before the medical and pharmaceutical students of the University of Texas, and communicated by the author.—*American Druggist.*

sessed by one medical substance of neutralizing the therapeutic effect of some other remedy. Medicines possessing this property should never be ordered in combination.

In conclusion, gentlemen, I will state that I have not told you all that you should know concerning this very important subject, but I hope the suggestions which I have given may be fixed upon your memory by the illustrations you have seen this morning, and will incite you to a more exhaustive study of the subject.

When the physician has learned to write compatible prescriptions, and the pharmacist has so mastered his calling that he can dispense the same in a reliable, palatable and sightly form, then will the occasion for mutual criticism have disappeared and given place to mutual respect.

[Continued from SUPPLEMENT, No. 956, page 15280.]

STUDY OF SNOW CRYSTALS.

By Prof. Dr. G. HELLMANN.

(Translated for the SCIENTIFIC AMERICAN.)

Structure of Snow Crystals.—I pass now to observations on the external and internal structure of snow capillary, hollow spaces. Formerly these hollow spaces were only known to exist in the crystals having the form of six-sided prisms. In 1681 Rossetti observed this, and later Wilcke. There can be no doubt now that all forms of snow crystals contain these capillary hollow spaces. I observed it for the first time in a plate-shaped crystal, where they are usually larger and more easily observed, but they may also be distinctly seen in the rays of the star-shaped crystals. Here the hollow spaces are in the form of capillary tubes, which run out to a point at the ends, and lie symmetrically on both sides of the ribs. The inner elongation of these capillaries running parallel to each other usually amounts to from two to five hundredth part of a millimeter, and the tubes at their thickest place are about the same width. The outrunning points of these capillaries are turned toward the middle point of the star. Sometimes there lies before these ends, precisely in the prolongation of both capillaries, two or four diminutive hollow spaces, in form of a blister, which may be considered as the starting point of the formation of the capillary tubes.

It seems to me a fortunate circumstance that I am not alone in ascertaining the existence of these capillary hollow spaces. Herr G. Nordenskiold also points them out, especially distinct in tabular crystals. drawings, only those of Waters show hollow spaces—they are not seen in the drawings of Scoresby and Glaisher.

These capillary hollow spaces appear to me to be one of the most important characteristics of snow crystals, distinguishing them from other ice formations. I have never seen these hollow spaces in the frost figures upon the window panes, although cylindrical forms are seen, and fern-like ice formations, similar to a feathered snow star. As is well known, ice arising from frozen water exhibits a great number of air bubbles.

Another characteristic of tabular crystals, which deserves special mention, is the frequent appearance of narrow facets on their edges. I have only twice observed crystals with these facets, but the dark border on the tabular plates in Figs. 6, 8, 9 and 11 proves that they appear frequently. They are well developed in the tabular star, Fig. 11, which furnishes a beautiful model for a reel, also the two plates in Fig. 9 have beautiful facets. Unfortunately it has never been possible to measure the angle which the facets make with each other. Kamtz, who observed these facets, gives a drawing in detail of the vertical incisions of such a faceted snow crystal, from which Galle and Bravais have derived conclusions in regard to the

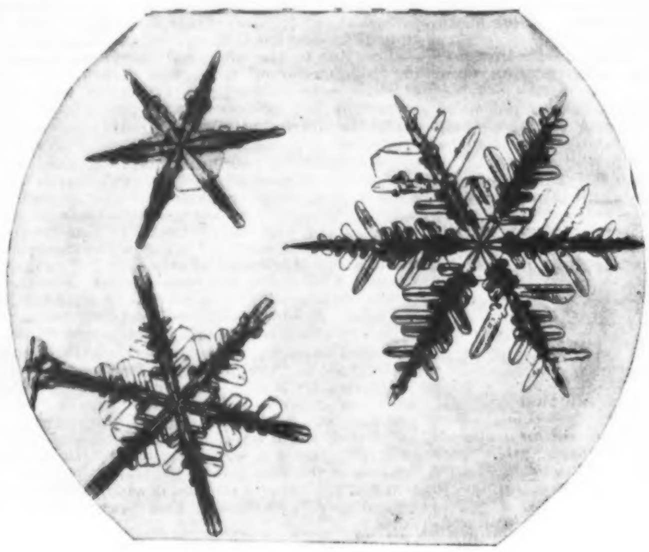


FIG. 5.

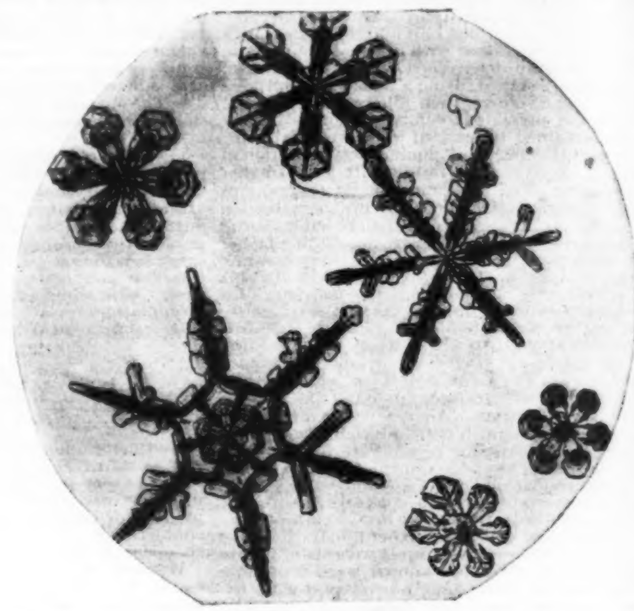


FIG. 6

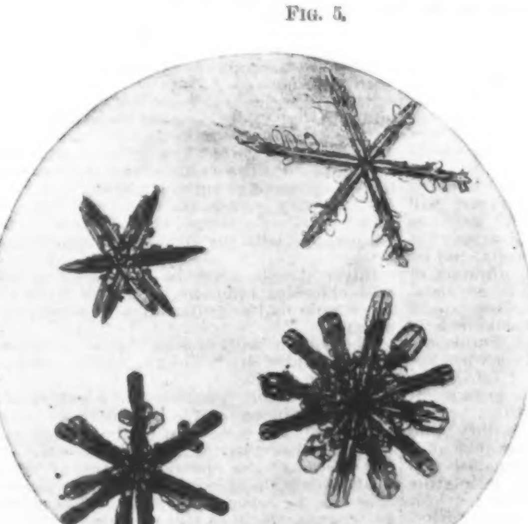


FIG. 7.

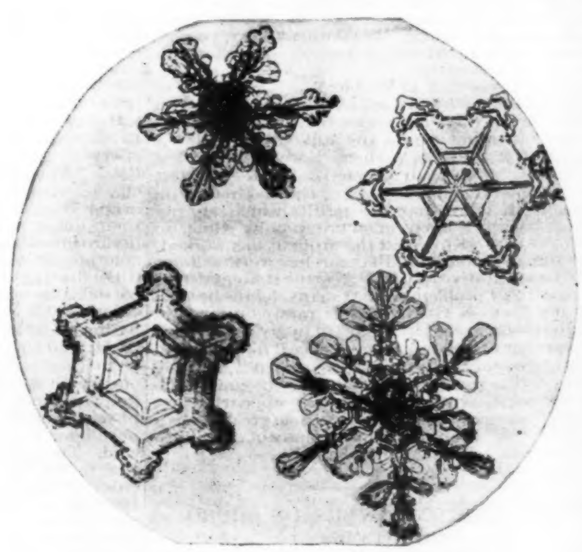


FIG. 8.

PHOTOMICROGRAPHS OF SNOW CRYSTALS.

crystals, which is the most important division of this attempt at their study. Here the photomicrographs have performed an excellent service, as by this process the crystals are firmly held, and accessible to every one. In direct microscopical observation, only a single crystal can be scrutinized, and that only in fragments, as the quickly changing contour and structure of the crystals make a lengthy observation of them very difficult, and often impossible. It is really surprising that such eminent observers as Scoresby and Glaisher discovered nothing in regard to the internal structure of these crystals, or at least published nothing about them. Possibly in their attempt to draw as many as possible they found no time to examine closely the conditions of their formation.

In examining the six-rayed stars and the forms derived from them we find that they have a principal ray and secondary rays, which are not always opposite each other. The strengthening or re-enforcing of the principal rays near their starting point, for a short distance of from 0·2 to 0·3 mm., is sometimes so strongly marked that it appears as if a smaller star were laid concentrically upon the larger one. This may be seen in Fig. 1*a*.

The most remarkable thing in the structure of the principal and secondary rays is this: they contain A good example is shown in the large star with tabular center at the left below in Fig. 6. In the inner star two symmetrical systems of hollow spaces may be observed by means of a magnifying glass; one of long drawn out blisters on the inner side of the edges, their long axes running parallel to the edges, looking not unlike six pairs of ants' eggs; then in front of these, in the direction of the center, and standing perpendicular to them, running almost in a radial line, a similar pair of smaller hollow spaces may be observed. It might be objected by some that these are simply points of melting, but their appearance is against this. Melting points look quite differently. Besides, the symmetrical arrangement of these capillary hollow spaces could not depend upon a mere accident.

Is it not a most interesting fact that these capillary, hollow spaces are shown in the beautiful drawings made by Rossetti in Turin, more than two hundred years ago? In the *facsimile* of his drawings, Figs. 5 and 10 show these spaces distinctly. This speaks well for Rossetti's talent for observation. These characteristics were well known to him, in the formation of that class of snow crystals called by him "rosettes;" on account of their great brilliancy he called them "gioie" (jewels), and made various remarks upon them without finding out the correct explanation. Of the later theory of the rings about the sun and moon. Hollow spaces appear in all the prismatic forms. Their form and position cannot be clearly perceived in our photo-engravings. The or iginal pictures, also observation with the microscope, show that the hollow spaces lie in the direction of the principal axis. Until recently it has been supposed that these hollow spaces contained only air, but Herr G. Nordenskiold, on the 8th of February, 1893, in Stockholm, made the interesting observation that ice prisms falling on that day contained both air and water, the temperature being −8°.

Beautiful examples of twin crystals may be seen in Fig. 4. The crystals, looking somewhat like a cauliflower, seen in Figs. 10 and 12, may be new. They probably originated by a regular snow crystal, in falling to the ground, passing into a stratum of air, which contained uncongealed water drops; the drops, by coming into contact with the snow crystals, were stiffened into amorphous ice.

Dimensions of Snow Crystals—Dependence of Size and Form upon the Temperature.

We are able now, by means of the photomicrographs, to take all the time necessary for the measurement of the snow crystals. While in direct observation under

the microscope such measurements had to be made very quickly.

In drawing snow crystals in the winter of 1882–83, I observed that the pure star-shaped forms were, on an average, larger than the tabular crystals. In making a number of measurements, I found the star forms had an average diameter of 2·8 mm., the tabular forms 1·9 mm. Comparing these forms in the photomicrographs, I find a complete confirmation of my observations for the last eleven years. The largest snow crystal shown in the photographs is the rudimentary star in Fig. 2, which has a diameter of 7·2 mm. The smallest tabular crystal is shown in Fig. 9; the diameter is only 0·3 mm. Scoresby discovered that the stars were larger than the tabular forms. Rohrer also remarked the difference.

If it is assumed that for the formation of snow crystals of both forms, at the same temperature, the same

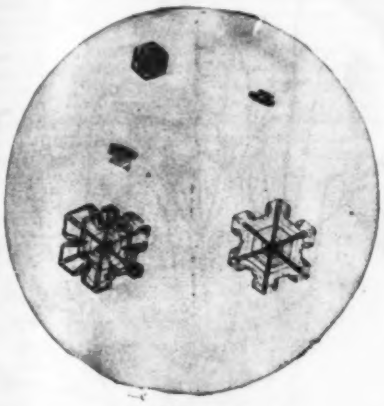


FIG. 9.

amount of aqueous vapor is used, it is easily understood that the compact tabular form must turn out smaller than the radiated star. From a regular hexagon of 1 mm. diameter one could make a star of nearly 22 mm. diameter. Of the dimensions of six-sided prisms we cannot make as accurate a statement, because the number of observations is much less. In the same snowfall the proportion of the length to the thickness usually remains about the same.

Another question which requires close investigation is the dependence of the size of the snow crystals upon the temperature.

Scoresby knew that, "as the cold increased, the size of the crystals diminished." Fritsch and Rohrer also observed this. I noticed the same thing in the winter of 1882-83, when I made my measurements of crystals. At –10° C. the crystals were nearly three times smaller than at –2° C. The photomicrographs, which permit closer measurements, give analogous results. The explanation of this is very simple. With diminishing temperature, the capacity of the air for containing aqueous vapor is diminished; under equal conditions, the size of the snow crystals diminishes.

This explains the remarkable smallness of the snow crystals in the polar regions—"diamond dust." Snowfalls at a temperature of from –20° to –40° C. are not uncommon in the Arctic regions. At –30° C., one cubic meter of saturated air contains only 0·5 gramme of aqueous vapor; at –6° C., 3·2 grammes; at –8° C., 27 grammes; and at –12° C., 2·0 grammes.

The temperature affects not only the size of the crystals, but also their form. Early writers asserted that at a certain temperature certain forms of snow crystals would appear very frequently or rarely. Opinions are quite contradictory in regard to this statement. In later times Fritsch and Tissandier deny such connection, stating that all the forms they have observed make their appearance at high as well as low temperature. This is correct; but if an investigation is made as to which form of crystal predominates at different degrees of temperature, it will be found that there is a certain conformity to law. The photomicrographs gives us the following per cent.: In thirty-one snowfalls at a temperature of –6° to –7·5° C. there was found to be 52 per cent. of star-shaped crystals, 22 per cent. of stars with tabular spreading at the point of the rays, and 26 per cent. of tabular crystals.

In twenty-one snowfalls at a temperature of –9° to –12·5° C. there was 24 per cent. of stars, 19 per cent. of stars with tabular ends of the rays, and 57 per cent. of tabular crystals. This distinctly shows that with diminishing temperature the number of tabular crystals increases and the number of star-shaped crystals diminishes. Dogiel, in his experiments of producing the forms of snow crystals artificially, arrived at the same results. He says: "In my experiments, I obtained a predominance of tabular crystals when the heated alcoholic solution in a test tube containing 15 to 30 per cent. of iodoform was placed for ten minutes in water from 14° to 15° C.

Star-shaped crystals and some complicated groups of crystals appeared when the test tube was placed in water from 26° to 27° C.

New Classification of Snow Crystals.—I have been led by my own investigations and the observations made and published by others to make a new classification of snow crystals. Scoresby, whose system of classification has been generally adopted, assumed five foundation forms of snow crystals. It seems to me more appropriate to give more value in the classification of the crystals to the fundamental rules of crystallography.

The hexagonal system to which snow crystals belong possesses three equal axes, which intersect each other in the same plane at an angle of 60°; the fourth axis is not equal to these three, and stands perpendicular to their point of intersection. This last is called the principal axis; the three others are called secondary or transverse axes.

I classify snow crystals under two principal heads with several subdivisions.

I. Tabular snow crystals; that is to say, those with a predominating flat development in the plane of the secondary axis, N. With these the principal axis, H, is very short: $\frac{H}{N}$ usually smaller than 0·1.

1. Radiated stars.
2. Plates.
3. Combination of both.

II. Columnate crystals; that is to say, those with a tolerably regular development of the four axes.

1. Prisms.
2. Pyramids.
3. Combination of tabular and columnar.

I make use, also, as a principle of classification of the proportion of the length of the principal axis, H, to that of the secondary axis, N, or the greatness of the quotient $\frac{H}{N}$. With the first type of crystals the numerical value is usually smaller than 0·1; with the second it varies between 1 and 5.

By far the greater number of crystals belong to the first type. Indeed, it may be said that only crystals of this kind are generally known. From my own observations I find that the tabular and star-shaped crystals form nearly 80 per cent. of all the forms observed. In the polar regions a like proportion is found, for, of the ninety-six figures given by Scoresby, we find only seven which belong to the second class. Rohrer, who also took the temperature into consideration, found a greater predominance of the first principal division, namely, 90 per cent.

It will be very near the truth to assert that three-fourths of all snow crystals belong to the first class.

In regard to the regular six-sided prisms, it may be said that they are seldom observed. The height of these prisms is seldom less than the diameter of the base. In those I have observed the proportion of the length to the thickness varied between 1·5 and 4·5. We know little of the frequency of the appearance of the six-sided prisms; but, as is known, the existence of these prisms in the atmosphere is advanced as an explanation of the rings about the sun and moon. In this case they must appear much more frequently than they are observed upon the earth. Pyramids appear to be the rarest of all forms of snow crystals. I have never seen them. Scoresby observed them once. Undoubtedly there are a large number of snow figures which are not contained in our system of classification, but they represent no foundation forms, but are only a conglomerate of such forms. They have, at the most, only an appearance of crystallization, but are not crystals.

Origin of Snow Crystals.—Of the origin of snow crystals in general, there exists scarcely a doubt. Many facts prove that snow crystals are formed immediately from the aqueous vapor in the atmosphere, without passing into a fluid condition. There follows

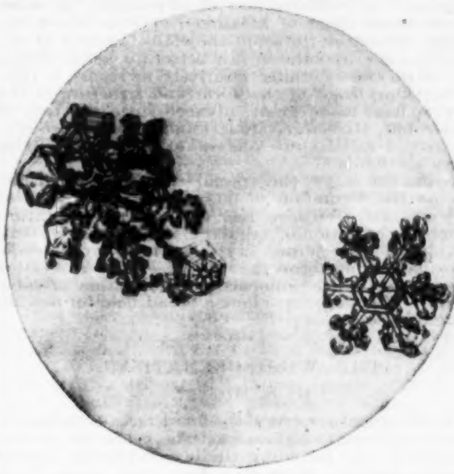


FIG. 10.

a direct transition from the gaseous state to the solid state—a sublimate.

Muncke, in the year 1816, showed some beautiful experiments of this process of sublimation. He placed a small quantity of ice at one side of a glass globe, put it on the sill of an open window, in a room where the temperature was somewhat warmer than the outside air, so that the side of the globe which contained the ice was toward the room. When the warm air of the room rushed through the globe to the outside, invisible small particles of ice quickly rose as vapor, from which originated beautiful and regular snow crystals on the opposite side of the globe.

Since then similar occurrences in nature have been observed, especially in balloons and in the polar regions. Tissandier treats of this subject in his book "L'Ocean Aerien." Other accounts tell us of travelers in the polar regions who, with a clear, blue sky above, have seen snow crystals form in the lowest stratum of the atmosphere. At great heights, as well as in the Arctic regions, the moisture from the breath may be seen changing into microscopic ice crystals. We have accounts of snow forming in warm rooms by the sudden entrance of cold air. It is said that a snowfall occurred in an overcrowded saloon, at St. Petersburg, in which, some ladies fainting from the heat, a gentleman quickly broke in a window, letting in suddenly a rush of cold air.

The opinion advanced in some of the old text books, and also in some of the later ones, that the atmospheric downfall appears as snow when the water condensing from the aqueous vapor immediately freezes, must be held as untenable. If downfalling drops of water which have a higher temperature than zero suddenly freeze, ice crystals never appear, but amorphous ice globes, which fall as sleet.

We may assert with great probability that the starting point or the germ of snow figures is to be sought in the little microscopical snow points which are met with abundantly in the higher stratum of air and in the polar regions. The smallest snow figures are found in the polar regions, because their place of origin lies

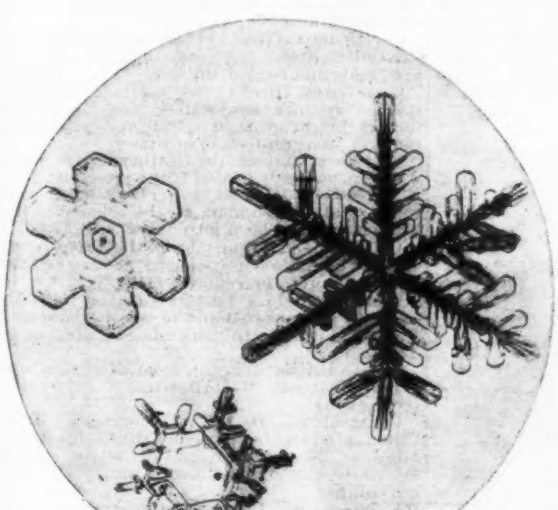


FIG. 11.

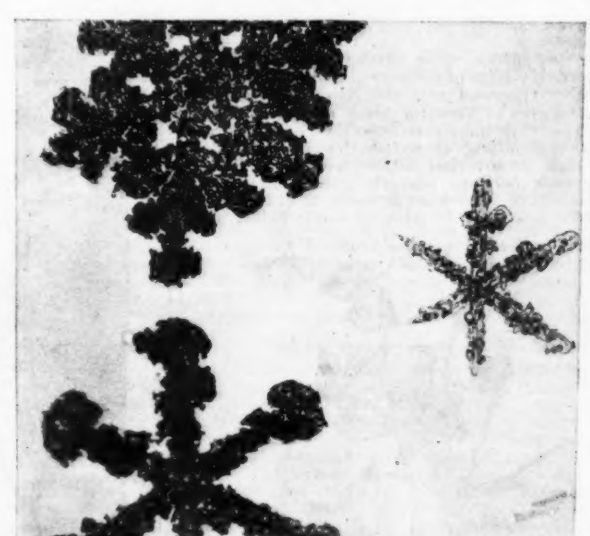


FIG. 12.

PHOTOMICROGRAPHS OF SNOW CRYSTALS.

so near the ground. They have no opportunity in their downfall for further development.

The origin of snow crystals is, without doubt, similar to the separation of crystals in a warmed salt solution. At first small crystals form upon the surface, which as specifically heavy bodies fall slowly to the bottom, and during their fall visibly increase, until they lie upon the bottom of the vessel in large flakes.

In the year 1790, Monge compared snow flakes to flakes of salammoniac, originating in this manner. The capillary hollow spaces, or air blisters, which appear in all snow crystals, originate with them, and may be explained in the same way as the air bubbles which are found frequently in ice and hail stones.

The most difficult question of all remains, the cause of the various forms of hexagonal crystals, which frequently change in the same snowfall. Instead of advancing a new hypothesis, it is better to acknowledge that we no know nothing positively in regard to this. In our knowledge of the form and structure of the snow we have made great advance since the time of Kepler, but, after nearly four hundred years, we cannot give a satisfactory answer to his question "Cur autem sexangula?"

We do not know the special conditions which determine the formation of one or the other form of snow crystals. We have seen that a low temperature favors the formation of tabular crystals, a higher temperature the star-shaped crystals; these groups show such multifarious forms that it is necessary to seek for other causes which influence the formation of snow figures. There is offered here a broad field for new investigation and study.

THE WILD CLEMATISES.

By S. MOTTET.

AMONG clematises, one of the finest races of our hardy climbing plants, two classes may be made for garden purposes: one, including the large-flowering garden varieties, such as those that have been raised from crosses or selections of C. patens (De C.), C. lanuginosa (Lindl.), and C. hakonensis (Franch. et Savat); the other including all the introduced species which have kept their characters under cultivation or have given rise to but a few varieties. In the eyes of florists, the former are by far the better and much more esteemed.

CLEMATIS CIRRHOSA.

Hundreds of varieties are now grown, but they are rather delicate.

Those of the second class, although having smaller flowers, have a charm of their own, which they owe to their hardy, vigorous, and free-flowering character. These in the eyes of the true lover of plants are the finer, because they have kept their own natural grace.

The hardy-climbing clematises have many uses in gardens, such as covering arbors, trellises, walls, etc., but they look perhaps best when climbing upon old trees or hanging in elegant festoons from the tops of ruins; they may also be planted along walks, where

CLEMATIS VIORNA.

three poles tied together at the top provide a convenient support for them; in rockeries and the wild garden they may be let to ramble at will over the stones or on the soil, and for garnishing the front of buildings, balconies, etc., they are almost unrivaled. The wild clematises only will be dealt with in this paper.

Clematis orientalis (Linn.),* sometimes known in gardens under the name of C. graveolens, is perhaps the best of the half-dozen yellow species introduced. It is quite hardy, and flowers most profusely from August to October. It was introduced as long ago as 1771, from the Himalayan regions. The flowers, from 1½ inches to 2 inches across, are bright yellow, hardly scented, borne singly on peduncles from 3 inches to 4 inches long, and forming by their union clusters in the axils, or rarely on the top of the shoots. The sepals are four in number, or very rarely five or six, oval

* Clematis orientalis (Linn.)—Lavallee, *Aboret. Segrez.*, t. 29; *Clematites*, t. 21; C. graveolens (Lindl.), *Journ. of Hort. Soc.*, i., 307, cum ic.; *Bot. Mag.*, 4,495; *Fl. des Serres*, vi., t. 548; *Jard. Fleur.*, t. 198. C. flava, De C.

lanceolate, mucronate, spreading, almost flat, downy, and recurved on their edges.

The fruits or carpels are olive green, with some scattered silky hairs, and their styles are long, feathered, dirty white, and quite reflexed; they form conspicuous and numerous downy heads, looking much like those of our Virgin's Bower or Traveler's Joy. The leaves are opposite, long-stalked, bearing three to seven leaflets, green on both sides, quite glabrous, and with their edges more or less frequently and deeply cut; the secondary stalks often twist themselves against

CLEMATIS GRAVEOLENS.

neighboring objects, acting the part of tendrils to assist the plant in its way up the trees.

C. montana (Buchan)* comes next in merit to the above; its flowers are pure white, 1½ inches to 2 inches or even 3 inches in the variety grandiflora, and look much like those of Anemone sylvestris; their stalks, 6 inches long, without bracts and one-flowered, make sessile clusters in the axils. The leaves, with rather long stalks, bear, as a rule, but three closely-set and shortly petiolate leaflets, which are toothed at the base and quite glabrous. This blooms in spring and beginning of summer, and is quite as vigorous and hardy as the former. It was introduced about 1831, from temperate Himalaya, Sikkim, etc., where it grows at 6 000 feet to 10,000 feet.

C. Viticella (Linn.)† is another important species of very variable character, and differs entirely from the former. The flowers are blue, violet, purple, pink, or sometimes pale white, from 1 inch to 2 inches broad, borne singly in the axils, or sometimes three to seven together on the top of the shoots, with very long slender stalks. The stems, which are at first slender and four-angled, never become large. This is one of the oldest inhabitants of our gardens, growing wild in the Mediterranean region, from Italy to Central Asia; hardy, but liable to be cut down by severe frost. There are a few varieties, notably a double one, which is

CLEMATIS DAVIDIANA.

purplish violet colored, hardier and taller climbing than the type.

C. flammula (Linn.) is a near ally of our wild indigenous species Old Man's Beard (C. Vitalba), but with larger flowers, of a creamy white shade, very sweetly scented, not woolly outside, save on the edge. The leaves are also quite different, being bipinnate, with small, thickish, entire leaflets and much twisted stalks, while the leaves of C. Vitalba are simply pinnate, with five large, thin, and coarsely-toothed leaflets. Both plants have small, but innumerable flowers, which expand from July to September, and a woody stem. C. flammula grows wild in the Mediterranean region up to the center of Europe, while C. Vitalba extends to the north.

* Clematis montana (Buchan).—*Bot. Reg.*, 1840, t. 58; Sweet's *Brit. Fl. Gard.*, ii., t. 253; *Rev Hort.*, 1856, t. 48; var. grandiflora, *Hort.*; *Bot. Mag.*, 4,061; C. anemoniflora, D. Don.; C. napalensis, De C.

† Clematis Viticella (Linn.), *Bot. Mag.*, t. 565; Reich. *Fl. Germ.*, iv., t. 65; Sibth. *Fl. Graeca*, t. 516; Lavallee, *Clematites*, t. 7; Viticella deltoidea, Mœnch.

Among other wild climbing and hardy species introduced into gardens, but not so generally grown as the above, we may mention:

C. aromatica (Lenne and C. Koch), with deep, blue-violet flowers, smelling like heliotrope, and whose stems attain about 6 feet. Its native country is unknown.

C. campaniflora (Brot.), from Portugal, with purplish white half-opened flowers, and leaves bearing about twenty-four leaflets.

C. cirrhosa (Linn.), from South Europe, with creamy

CLEMATIS ÆTHUSIFOLIA.

white, involucrated flowers and persistent leaves. C. balearica (Rich.) is now referred to this species.

C. crispa (Linn.), with pale lilac or purple bell-shaped and nodding flowers.

C. eriostemon (De C.) (C. Hendersoni, Hort.), with blue-violet, widely-opened and solitary flowers. It is supposed to be of North American origin.

C. indivisa (Willd.), from New Zealand, with creamy-white paniculated flowers.

C. paniculata (Thunb.), from Japan, a small flammula-like flowered species.

C. Pitcheri (Torr. and Gray), from North America, with dull purple tubular, strangulated, solitary, and nodding flowers.

C. reticulata (Walt.) rather newly introduced from the United States, with campanulate flowers, pale yellow inside and reddish outside.

C. texensis (Buckl.) (C. coccinea, Engelm.), with small, very thick, long-stalked, and almost top-shaped flowers, bright crimson outside and yellow inside. It requires some protection in winter.

C. Viorna (Linn.), the leather flower from North America, is closely related to the preceding, from which it differs chiefly by its flowers not being conical and reflexed at the summit of the segments. It is also hardier, and has been introduced since 1730.

C. virginiana (Linn.), from the same country, has small, white, diœcious panicled flowers, and its shoots will climb up to 16 feet or 18 feet.

The non-climbing bushy clematises have also their value in gardens to decorate the herbaceous border, the rock garden or to form isolated clumps on the lawn. The best are:

C. æthusifolia (Turcz.), from Mongolia, with long, tubular, hanging, white flowers. It grows from 4 feet to 6 feet high.

C. Davidiana (De C.), (C. mongolica, Hort.), from China, produces axillary and thick clusters of porcelain-blue flowers of cylindrical shape, expanding as late as September. Its leaves are trifoliate and of a grayish tint.

C. integrifolia (Linn.), from Southern Europe, is distinguished by its entire, large, sessile and opposite leaves. It produces fine nodding flowers, deep blue inside and velvety grayish outside, on solitary and axillary peduncles, 6 inches to 8 inches long. It blooms in August.

C. ochroleuca (Ait.), from the United States, is similar in habit and shape of leaves, but its flowers are creamy white inside and yellow outside.

C. recta (Linn.), from South Europe, has very numerous small, white, and scented flowers, looking like those of C. flammula. The stems are herbaceous, more or less erect and do not exceed 3 feet.

C. stans (Sieb. and Zucc.), introduced in 1880 from Japan, has pale blue flowers, hanging, subverticillate and forming terminal panicles.

C. tubulosa (Turcz.), from China, has long, cylindrical light blue flowers, set in whorls on long, upright spikes. The leaves are opposite, long-stalked and bear three large oval leaflets. The stems grow upright to about a height of 2 feet. The C. Hookeri (De C.), referred by some authors to this species, differs chiefly by its lilac flowers.

This species, as well as C. Davidiana and a few others, have a quite special aspect, entirely different from the host of clematises, and which they owe to their narrow tubular flowers, looking like florets of hyacinth, besides their herbaceous and bushy habit.

All these non-climbing clematises do not become

woody at the base and die, or are cut down to the soil by the frost. They may be treated just like herbaceous perennials, which they are in fact, and are easily propagated, when seeds fail, by dividing the roots in spring.

The species described above, and more especially the first-named, are hardy and need but little or no care when once established. Pruning is not necessary beyond the cutting in to due limits or taking away the dead parts. Most of those here noticed bloom on the young wood and may be shortened at will; but C. montana blooms on the wood of the preceding year, and this must of course be preserved for the sake of the flowers.

As a rule, clematises like a deep, sandy loam, rich and well drained; some refuse to grow where there is chalk, others do not mind it. Watering in dry weather, and especially during the season of growth, materially assists them, and some liquid manure may be given with benefit. When seeds are produced this is the easiest mode of propagation, but as they do not retain their germinating power for a long time, they are best sown when ripe, outside or under a cold frame. They may also be mixed with fresh sand in a pot or box and sown the following spring.

Layering is also an easy and sure process, useful for amateurs, as the layers root generally the first year. Young cuttings of most varieties may be struck in heat, and grafting in heat, under bell glasses, on roots of C. Vitalba, C. Viticella and others, is the way by which nurserymen propagate garden varieties or any delicate or scarce species.

CLEMATIS MONTANA.

A GREAT BARN.

FOR six months there have been actively engaged at Ellerslie, near Rhinebeck, Dutchess County, N. Y., Mr. L. P. Morton's stock farm, all kinds of workmen employed, rebuilding the barn destroyed by fire on August 2, 1893, and it may be said it is the only work that has been going on in the town for the past six months, and the benefit derived has been great to this community. While Mr. Morton has been in Europe he has been helping his fellow townsmen very much, contributing to their support by giving them work. The general plan from which the barn was rebuilt this year is the same as drawn by Mr. Dudley Newton, architect, of Newport, under whose supervision the builders, Ackert & Brown, worked last year. There have been some very decided improvements carried out this year that were not in the barn last year, and, upon the whole, the structure is a much better one.

It was rebuilt by Ackert & Brown, of our town. Mr. Morton has added to the barn some extras which were not considered in last year, and greatly added to its cost, and upon the whole they have been worth the time and expense. To appreciate the amount of labor and material in the barn, it needs to be seen, and then it begins to dawn upon the mind of the beholder what it is to build a barn and have all first-class appointments.

The barn is 297 ft. long, 65 ft. wide and 50 ft. in height, with an L 89 ft. by 52 ft. The barn includes, besides, three 500 ton silos, each 47 ft. deep, a tool and engine room, lavatory and bath room, grain bins, and ample hallways, no less than 120 common stalls, and 46 box stalls on the main floor, and an equal number are placed in the basement, which is light and airy, its floor bottom being level on one side with the ground, while on the other side its windows are protected by an area wall, having a heavy coping on top guarded by an iron pipe fence 4 ft. 6 in. high.

The bays above the stalls accommodate 400 tons of hay, without covering over the corridor, and the grain bins will hold 20 car loads of grain. The main door on the south, looking up through the center of the building, is large enough to admit an engine and train of cars, and it would have more than ample room inside, the passage being 16 ft. wide and 39 ft. high in the clear. The cows stand in two long rows in the basement; on the main floor they are placed head to head, with a wide feeding alley between them, and back of them are the rows of large, roomy box stalls for calves, bulls, and lying-in cows. In laying out the plans, no point of hygiene, comfort or convenience seems to have been overlooked; the basement is made light and airy, windows run to the bottom and give an abundance of light; the air is kept pure by means of box ventilators running from the basement and out of the roof of the lantern. These ventilators are also used as a hay chute, to convey the hay from the loft to the main and basement floors.

The ventilation for the main floor is operated by opening the lantern sash, which has 78 in number, and are attached to a shaft that runs the whole length of the lantern, and a perpendicular shaft running down to the main floor operates six sashes at once.

On the main floor the windows are fitted up with blinds and hung with Worth's patent awning blind hinges, and they can be used as a common blind, and also be adjusted so as to form an awning. The gutter on the outside of the building is of galvanized iron, and patented by Mr. Dudley Newton, of Newport, and was only used by privilege on this barn, as Mr. Newton, the architect, last year used it, it being his own, and the builders this year were granted the privilege of using the same style of gutter. There are 15 conductors, 8 of which lead the water to the bottom of the area on the east side of the barn, the bottom of the area forming a gutter to carry the same around the south end of barn into a drain. In this way the water is carried away from the barn. On the west side the conductors connect in a system of tile drain which carries the water to a main drain.

It required 250,000 ft. of yellow pine timber and 250,000 ft. of spruce to construct the building. It also required 310,000 shingles to cover the roof and sides from the brick wall. These shingles are cedar. After using all the brick that were good that passed through the fire, there were purchased 330,000 brick. Carpenter work was begun August 10, and the frame was framed by the system of box framing, not usually done in a barn; the timber was all planed yellow pine; all work was done in the most workmanlike manner, and must cast favorable reflection upon the builders. There have been actively engaged in the rebuilding of the barn about 100 men steadily employed, divided up into about 70 carpenters, 10 masons, and 20 laborers. These men have been under the immediate supervision of Ackert & Brown, the builders, and we should judge it must speak well for the firm to have built the barn and then have established themselves so well in Mr. Morton's confidence that he could go to Europe and leave the barn in their hands to rebuild, so complete in every detail, with all the labor employed; there has been given by the builders work to men who have applied, living in this community, and it has been a great help, not only to the builders, but to the men in their employ, who appreciate their efforts and Mr. Morton's generosity. There was paid to workmen about $20,000, and, in these times, when men are curtailing their expenses, this money has done a great amount of good.

The main floor of the barn is made of 2 by 9 spruce tongued and grooved, plain side laid down, and then there was applied a coat of tar, then 3-ply tarred paper was laid on it which was covered with tar, on this for a finish floor 1¼ by 5 in. tongued and grooved spruce was laid, making a floor 3¼ in. thick and perfectly water tight. In the rear of the common stalls on the main floor is a gutter, 19 in. wide and 8 in. deep at the deepest part, the bottom slanting to 4 different traps in it to carry to the main drain which conveys everything to the cesspool, when it will be pumped in a sprinkler and drawn out and sprinkled on the land.

The cows in the common stalls are secured by the Watters patent fire escape and labor saving fasteners by which animals, whether two or fifty, occupying stalls in a row, can be set loose instantaneously by pulling a lever attached at the end of each row 1½ in. A child can do it; the chain drops to the floor and releases the cow; a single animal can be released with greater ease than when fastened in the usual way. The cows have constantly before them fresh water in iron buckets, supplied with the Buckley device, which has been provided with wooden covers, to prevent hay and feed from getting in. The furniture and iron work in the barn is perhaps the best that could be had for its several uses. The barn door hangers are the Coburn patent rollers, and it has been decided that they are the best roller in the market. The fastenings for doors are mostly of the Worthilip box stall door latch, with brass cup handles inside and out. The fastenings for stall doors are Conray's extra heavy refrigerator door fasteners, which are used on the doors of the ventilator chutes. All fastenings and hinges are galvanized, to prevent rusting. Behind the common stalls is Stewart Bros. self-cleaning stable grating, which covers over the gutter and makes the cows stand on a level. These gratings passed through the fire and were taken apart and straightened, speaking well for the material of which they were made; this being the only iron which passed through the fire and was used again in the barn. The box stalls have T gutters leading to the main gutters in the barn. The overhead trolley track has four lines on each floor. Carriers are provided to carry cars with feed to the cattle and also to carry manure to manure shed, where it is dumped in wagons and then carried out and spread upon the land. The track and carrier are so arranged that each carrier can be run upon every track by the use of turntables and switches; track guaranteed to carry 5,000 lb., and to be easily moved by one man. In the ell part there is a hay carrier to unload hay or grain, with the use of sling, and deposited at any spot in the mow. It is calculated for three slings to the load, a great improvement on the patent hay fork. The system of drainage is the best that can be used, especially for cleanliness. There is one main drain in the east side of the barn, in the basement, running the whole length of the barn, consisting of an 8 in. steel pipe, put together in sections, and 4 cross drain pipes from the gutters above, carrying everything from the gutter to cross gutter at the north end of stable which leads to cesspool. The main gutter in basement is made of concrete, the bottom of which slopes to the main cross gutter which empties into the cesspool. The basement bottom is made of concrete 6 in. thick, with brick piers to accommodate chestnut sleepers, which carries a 2 in. floor of spruce, where stalls are put in and fitted up same as on the main floor.

The water pipes in the basement are all covered, to prevent freezing. In the L part of basement there is a root cellar, which can be filled from the main floor through a trap door. Three compartments in this cellar, with a shelf partition in each, made of slats 1 in. apart, 1¼ by 5 in. spruce. The barn is fitted up and completely lighted with electric light, put in by Mr. B. W. Philbrick, electrician and engineer, who is constantly employed on the place doing all plumbing, gas and steam fitting. There are 30 lights in the barn run from storage batteries. The electric heat alarm system is extended throughout the barn. A thermostat being placed 15 ft. apart on every floor, on the roof and in each ventilator, closet and room. At no point can heat rise above 140° without the alarm being given in the farm house by the ringing of a large gong over the main south door of the barn, on the outside, and so long as the heat continues the bells will ring and continue the alarm. There is over the main door to the superintendent's office, outside, an indicator that records the place where the heat or fire is. There are in the barn 300 thermostats and 6 miles of wire, it being the largest stock barn ever fitted up with the heat alarm system. Connected with this alarm in the superintendent's office is an ingenious clock, by which the superintendent can test daily and see that the whole system is in perfect order, testing every thermostat and every inch of wire in the whole system. An engine, 25 horse power, is used to run the ensilage cutter, feed mill, elevator, and saw. A line of shafting runs through the ell part of the barn, with sufficient number of belt pulleys on to run each piece of machinery. All journal bearings are protected by a thermostat, and should heat rise to 140°, alarm will sound by the ringing of a bell over the door to the engine room, where there is an indicator showing upon which shaft the journal is hot.

The steam for the engine is conducted to it under the ground from the power house, which is situated about 300 ft. away. There is a bone mill, so that they can grind meat and bone for their chickens. The elevator for elevating grain into the bins is of the Jeffres patent, and has a capacity of 300 bushels an hour. The feed mill is so arranged that the grain can be let in the hopper in just the proportion they wish to grind, when the elevator carries it back to the bins, ground, when, with chutes, it is loaded in cars and conveyed to the cattle in their stalls and fed to them as desired.

All the work of rebuilding has been under the superintendence of Mr. H. M. Cottrell, superintendent of Ellerslie, who has given his immediate attention to all the work in detail, and the success of the building and rapidity with which it was constructed was all due to him, and it will pay any person who wants to spend a short time pleasantly to visit the barn and see the many improvements developed in its building.

THE BROODER HOUSE AT ELLERSLIE.

At the time Ackert & Brown were building the barn they had a gang of men building an incubator and brooder house, one of the largest and best in the United States. This department is under the immediate supervision of Mr. James H. Seeley, who has had Mr. Morton's chickens in charge for nearly two years. When the fire came which destroyed the barn last year, it also destroyed the incubator and brooder houses with all the stock of chickens. When they got ready to rebuild, they located the buildings farther away from the barn. They began the first plant in August last, by building 6 hen houses, to accommodate 600 laying hens. Sufficient number of hens were bought to start with, and then came the erection of brooder houses to raise and care for the small chickens, which are to be hatched with incubators and raised for fancy market broilers and larger ones for roasting.

The hen houses are fitted up with electric wire, and no person is allowed or can cross the threshold of the door or open the windows without ringing a bell in the house; also it will ring a bell in the room in the incubator house, where the man sleeps. Chicken thieves stand a poor show to get a living around these houses. They are built for winter laying hens. The size of the hen houses are 16 by 54, made in three sections, two rooms in each section, one room for laying and roosting, the other one is for exercise on bad, snowy, or stormy weather, there being no floor but the ground. Down under the top of the ground is placed wire netting to prevent rats from getting in or making a home in the building. The room for laying is fitted up with movable nests, 12 in number; in each cabinet and in each room are crates to confine hens that want to set, as they have no use for setting hens; the incubators do all their work.

All hens purchased are white Monarchs, white Plymouth Rocks, white Wyandotts, sprinkled with a few light Brahmas. It is wanted to have hens enough to

lay eggs to supply the incubators, which require 150 daily.

The brooders and incubator houses are located in the same space of ground, between the six hen houses, is perhaps the largest plant of the kind in the United States.

The two brooder houses are 132 ft. long by 18 ft. wide, and are fitted up with all the improvements and labor saving devices. In each of houses there are 25 pens, 5 ft. by 15 ft., which will accommodate 2,500 chickens. There is a 3 ft. hallway running in front of the pens to feed from, also being very convenient to do all the necessary work. In each pen there is an artificial brooder, heated with hot water pipes, it requiring half a mile of hot water pipes in these houses to give the necessary heat from a Gurney hot water heater.

The pens are furnished with water fountains, feed troughs, and boxes for dust and ground. The floors are of spruce, underneath which is fine hardware cloth, to prevent mice and rats from getting the young chickens. The frame is of planed hemlock, and a lantern is placed in the center of each building which furnishes light and ventilation. The sash is operated by a device from the hallway, and opens six windows at once. Each pen has a window and also an opening to let the chickens out into the yard on the south side of the houses. The slides are placed upon a movable frame, and with one pull of a lever in the incubator house, every pen can be opened or closed at once, and, by changing the slide, any number of pens can be opened or closed at will. In each house there are five solid partitions of wood, so that one part of the brooder can be shut off from the other, and the partitions between pens are of 1 in. mesh wire, and about 20,000 ft. of wire was used in brooder houses and yards.

The brooder houses have a capacity for 5,000 chickens at once, and they will be graded from the chickens just taken out of the incubators to those weighing 4 or 5 pounds. Mr. James H. Seeley, the manager of this department, aims to produce all white chickens for market. The incubators are heated with gas from a gas machine, being in every way complete, heating the incubators accurately, at the same time furnishing light for the building. There are 10 Puieland incubators in this building, with a capacity of 300 eggs each, and when the plant is in full operation, it will require three men, besides the manager, to do the work and care for the hens and young chickens. They expect to raise 20,000 broilers a year. The duck house is east of the brooder house, and the young ducks will be hatched out in the incubators and they expect to put upon the market 5,000 ducks annually, all of the white Pekin variety. The incubator house has, besides the room for incubators, an office for the manager, feed rooms for mixing and storing feed, a picking room, a room for gas pump and weight, and a hallway connecting all rooms with brooder house and stairway to bedroom.

This plant is under the immediate supervision of Mr. James H. Seeley, and of course we know it is in good hands, as he is an encyclopedia on chickens.—*The Rhinebeck Gazette.*

COYOTE FARMING IN KANSAS.

FOR years the Western prairies have been fruitful in the production of that fleet-footed nuisance, the coyote. Surpassed in speed only by the antelope and particularly fast greyhounds, it is practically secure from harm. In order to keep down their rapidly increasing numbers, the Kansas legislature authorized in 1889 the offering by counties of a bounty for wolf scalps. Nearly every county in the State seized the opportunity and gave, in order to protect flocks and chicken yards, a reward of \$3 to \$4 per scalp. The result has been astonishing. Men have discovered that it paid better to hunt wolves than to raise crops, and several frontier counties have paid from \$3,000 to \$4,500 a year in bounties, the total in the State reaching \$60,000, with no appreciable diminution in the coyote supply.

This fact puzzled the commissioners of several counties, until it was discovered that farmers were making a business of raising wolves for the bounty to be secured. By means of wire fence inclosures with ample burrowing grounds, the creatures increase with marvelous rapidity. The growth of a family of kittens can alone be compared to them. For feed, the cheapest of meat is sufficient, and as nothing is required but the scalp in order to draw a bounty, the carcasses of the killed wolves are used for sustenance for those not ready for market. The best sheep that the prairie farmer can raise can scarcely be sold for more than \$2. To produce several litters of wolves a year, each member of which is worth from \$3 to \$4 exclusive of skin and carcass, is, it is seen, remunerative.

These wolf raisers also supplement their home supply by constant hunting on the plains. Parties are formed which surround creek valleys and ravines, "beating the brush" with as much skill as the trained retainer, and capturing, dead or alive, dozens of the lank, gray creatures. The former go to swell the cash account of the hunters and deplete that of the county treasury, while the latter are added to the supply on the wolf farm.

To hunt the coyote by means of native dogs is something humorous. No matter how fleet is the dog, it always has some of the conceit taken out of it when hunting coyotes. Once aroused to its danger, the Ishmael of the plains, lonely, stern and forsaken, takes its course over the level prairie at a rate which discourages the bravest. As Mark Twain says of the coyote of the alkali desert, it "cuts a long crack through the atmosphere, and the dog is suddenly alone in the midst of a vast wilderness." With greyhounds it is different. Their long, slender legs can overtake the fleetest of the plain's creatures, and the sport has become a fascinating one to the members of kennel clubs throughout the West.

Probably the most remunerative hunting is that by means of half-mile wires introduced by a New England land sportsman this winter on the prairies of western Kansas. Hitching a team to each end of a half-mile strand of wire, it is dragged over the curling buffalo grass, with a row of sportsmen, their guns ready for instant use, scattered behind it in a long row. The coyotes, rabbits, foxes, and prairie dogs, crouching low in their fancied security, are roused from their hiding places and go skurrying here and there ahead of the remorseless wire. When the cavalcade has made a half day's progress, the wire is swung around and another course taken homeward. Parties have in this way killed as many as a thousand jack rabbits in a single day and sent them to the charitable societies of Western cities. The harvest of coyotes has also been large, and the bounties received have made good return for the day's amusement.

Altogether the prairie wolf has proved a very profitable creature to the Westerner—so profitable in fact that it is likely that the legislature will be compelled to repeal the bounty laws, and farmers who have been making \$500 to \$1,000 a year out of the wolf industry will be driven out of business.—*St. Louis Globe-Democrat.*

THE FEIGNING OF DEATH BY ANIMALS.

THE feigning of death by certain animals, for the purpose of deceiving their enemies, and thus securing immunity, is one of the greatest of the many evidences of their intelligent ratiocination. Letusimulation (from *letum*, death, and *simulare*, to feign) is not confined to any particular family, order, or species of animals, but exists in many, from the very lowest to the highest. It is found even in the vegetable kingdom, the well-known sensitive plant being an interesting example. The action of this plant is, however, purely reflex, as can be proved by observation and experiment, and is not, therefore, a process of intelligence. The habit of feigning death has introduced a figure of speech into the English language, and has done much to magnify and perpetuate the fame of the only marsupial found outside the limits of Australasia. "Playing 'possum" is now a synonym for certain kinds of deception. I have seen this habit in some of the lowest animals known to science. Some time ago, while examining the inhabitants of a drop of pond water under a high-power lens, I noticed several rhizopods busily feeding on the minute buds of an alga. These rhizopods suddenly drew in their hairlike filaria and sank to the bottom, to all appearances dead. I soon discovered the cause in the presence of a water-louse, an animal which feeds on these animalcules. It likewise sank to the bottom, and after looking at the rhizopods swam away, evidently regarding them as dead and unfit for food. The rhizopods remained quiet for several seconds, and then swam to the alga and resumed feeding. This was not an accidental occurrence, for twice since I have been fortunate enough to witness the same wonderful performance. There were other minute animals swimming in the drop of water, but the rhizopods fed on unconcernedly until the shark of this microscopic sea appeared. They then recognized their danger at once, and used the only means in their power to escape. Through the agency of what sense did these little creatures discover the approach of their enemy? Is it possible that they and other like microscopic animals have eyes and ears so exceedingly small that lenses of the very highest power cannot make them visible? Or are they possessors of senses utterly unknown to and incapable of being appreciated by man? Science can neither affirm nor deny either of these suppositions. The fact alone remains that, through some sense, they discovered the presence of the enemy, and feigned death in order to escape.

Most animals are slain for food by other animals. There is a continual struggle for existence. Most of the carnivora and insectivora prefer freshly killed food to carrion. They will not touch tainted meat when they can procure fresh. It is a mistake to suppose that carnivora prefer such food. The exigencies of their lives and their struggle for existence often compel them to eat it. Dogs will occasionally take it, but sparingly, and apparently as a relish, just as we eat certain odoriferous cheeses. But carnivora and insectivora would rather do their own butchery; hence, when they come upon their prey apparently dead, they will leave it alone and go in search of other quarry, unless they are very hungry. Tainted flesh is a dangerous substance to go into most stomachs. Certain ptomaines render it sometimes very poisonous. Long years of experience have taught this fact to animals, and therefore most of them let dead or seemingly dead creatures severely alone.—*Atlantic Monthly.*

A REMARKABLE COMETARY COLLISION.

Two striking photographs are reproduced in the February number of *Knowledge* in illustration of an article by Prof. E. E. Barnard on the probable encounter of Brooks' comet with a disturbing medium on October 21, 1893. The comet was discovered by Mr. Brooks on October 16; but, though it was kept under observation at the Lick Observatory, no phenomena of an extraordinary kind were observed until the 21st of that month. A photograph, then taken with a Willard photographic lens, presented a remarkable appearance, the tail appearing, to use Prof. Barnard's analogy, like a torch streaming in the wind. The reproductions of the photographs give the impression that the comet's tail swept into some dense medium and was broken up by the encounter. Indeed, Prof. Barnard thinks it impossible to escape the conclusion that the tail did actually enter a disturbing medium which shattered it. This theory is supported by the photograph taken on October 22, where the tail is seen to hang in irregular cloudy masses, and a large fragment appears to be entirely separated from the main part. There is little doubt that the tail met a mass of meteoritic matter and so had its symmetry destroyed; at any rate, this supposition must be accepted until a simpler and better one can supplant it. What we have to do, as Mr. Cowper Ranyard remarks in an article on the irregularities of comets' tails, is diligently to collect facts. The multiplication of such photographs as those obtained of Brooks' comet and of Swift's comet (1892) by Prof. Barnard, will certainly revolutionize current opinion as to the development and the types of comets' tails.

A RECENT note from Canisteo, N. Y., contains the following:

The well recently drilled at this place by the Canisteo Oil and Gas Company, after it was shot, for some days produced no oil whatever, but a few days ago it began to show signs of oil, and has since produced about five barrels a day of lubricating oil. A peculiar thing about the product is that when a piece of white cloth is immersed in it and exposed to the light it at once turns a bright blue color, which is permanent. A committee of chemists has been appointed by the company to analyze the oil and choose a name for it. Parties engaged in the manufacture of calico in Oswego are negotiating with the owners of the well with a view to using the oil for dyeing purposes.

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